STANDARD TECHNICAL SPECIFICATIONS

FOR

O&MA PROJECTS, KOREA

REVISION 1 - 20151030

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT COMMAND

DEPARTMENT OF THE AIR FORCE
51ST CIVIL ENGINEER SQUADRON (PACAF)
UNIT 2129
APO AP 96278-2129

9 November 2015

MEMORANDUM FOR Chief, Construction and Supply Division, 411th Contracting Support Brigade, Korea, ATTN: CCEC-KOY-CB, Unit #15289, APO AP 96205-5289

FROM: 51 CES/CEN

SUBJECT: Revised Standard Technical Specification (2014) for O&MA Projects, Korea, Revision 1

1. The attached revision 1 (dated 30 October 2015) to the Standard Technical Specifications for O&M Projects, Korea, previous version dated 24 January 2014, will be applicable to all O&M funded construction contracts prepared for Air Force projects by 51 CES, 8 CES, and 607 MMS/CE, unless explicitly indicated otherwise in an individual contract, delivery order or task order.

2. The electronic version of the specifications is in an Acrobat PDF format and can be read with the Acrobat Reader software. In addition, request that the specifications be made available on the 411th CSB-Korea's web page at the same location as the previous version (2014) of the O&MA specifications, http://www.usfk.mil/Resources/ContractingwithUSFK.aspx.

3. Individual construction packages will list the specific specifications that apply to that contract, delivery order or task order. Clarifications and/or supplementation of these specifications will be included in each project's contract package. Additionally, when necessary, revisions and/or changes to the standard technical specifications will be included in a project contract package and take precedence over the content of these specifications.

4. Comments, suggested changes, proposed additions, improvements should be forwarded to the undersigned, wangsong.sin.kr@osan.af.mil, (DSN 784-5709), Engineering Flight, 51st Civil Engineer Squadron, Osan Air Base.

SIN.WANG SONG.1363639751

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WANGSONG SIN, Civ, USAF
Lead Engineer, Engineering Flight
51st Civil Engineer Squadron, Osan AB

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, UNITED STATES ARMY GARRISON, RED CLOUD AND AREA I
UNIT # 15707
APO AP 96258-5707

REPLY TO
ATTENTION OF:

IMRD-PW 9 November 2015

MEMORANDUM FOR Chief, Construction and Supply Division, 411th Contracting Support Brigade, Korea, ATTN: CCEC-KOY-CB, Unit #15289, APO AP 96205-5289

SUBJECT: Revised Standard Technical Specification (2014) for O&MA Projects, Korea, Revision 1

1. The revision 1 (dated 30 October 2015) to the Standard Technical Specifications for O&MA Projects, Korea, previous version dated 24 January 2014, will be applicable to all O&MA funded construction contracts prepared for Area I projects by Directorate of Public Works (DPW), U.S. Army Garrison – Red Cloud and Area 1, unless explicitly indicated otherwise in an individual contract, delivery order or task order.

2. The electronic version of the specifications is in an Acrobat PDF format and can be read with the Acrobat Reader software. In addition, request that the specifications be made available on the 411th CSB-Korea's web page at the same location as the previous version (2014) of the O&MA specifications, http://www.usfk.mil/Resources/ContractingwithUSFK.aspx.

3. Individual construction packages will list the specific specifications that apply to that contract, delivery order or task order. Clarifications and/or supplementation of these specifications will be included in each project's contract package. Additionally, when necessary, revisions and/or changes to the standard technical specifications will be included in a project contract package and take precedence over the content of these specifications.

4. Comments, suggested changes, proposed additions, improvements should be forwarded to the POC of Standard Technical Specification for OMA Projects, Korea, Mr. Michael C. DeMartelaere, michael.c.demartelaere.civ@mail.mil, (DSN 724-4887), Chief of Engineering Services Division, Directorate of Public Works, U.S. Army Garrison Yongsan.

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Daniel C. Hong
Chief, Engineering Services Division
DPW, USAG RC & Area I

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, US ARMY GARRISON-YONGSAN
UNIT #15333
APO AP 96205-5333

REPLY TO
ATTENTION OF

IMYN-PW 30 October 2015

MEMORANDUM FOR Chief, Construction and Supply Division, 411th Contracting Support Brigade, Korea, ATTN: CCEC-KOY-CB, Unit #15289, APO AP 96205-5289

SUBJECT: Revised Standard Technical Specification (2014) for O&MA Projects, Korea, Revision 1

1. The attached revision 1 (dated 30 October 2015) to the Standard Technical Specifications for O&MA Projects, Korea, previous version dated 24 January 2014, will be applicable to all O&MA funded construction contracts prepared for Area II projects by Directorate of Public Works (DPW), U.S. Army Garrison – Yongsan, unless explicitly indicated otherwise in an individual contract, delivery order or task order.

2. The electronic version of the specifications is in an Acrobat PDF format and can be read with the Acrobat Reader software. In addition, request that the specifications be made available on the 411th CSB-Korea's web page at the same location as the previous version (2014) of the O&MA specifications, http://www.usfk.mil/Resources/ContractingwithUSFK.aspx.

3. Individual construction packages will list the specific specifications that apply to that contract, delivery order or task order. Clarifications and/or supplementation of these specifications will be included in each project's contract package. Additionally, when necessary, revisions and/or changes to the standard technical specifications will be included in a project contract package and take precedence over the content of these specifications.

4. Comments, suggested changes, proposed additions, improvements should be forwarded to the undersigned, michael.c.demartelaere.civ@mail.mil, (DSN 724-4887), Chief of Engineering Services Division, Directorate of Public Works, U.S. Army Garrison Yongsan.

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Michael C. DeMartelaere
Chief, Engineering Services Division
DPW, USAG Yongsan

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, US ARMY GARRISON-YONGSAN
UNIT #15333
APO AP 96205-5333

REPLY TO
ATTENTION OF

IMHM-PWG 02 November 2015

MEMORANDUM FOR Chief, Construction and Supply Division, 411th Contracting Support Brigade, Korea, ATTN: CCEC-KOY-CB, Unit #15289, APO AP 96205-5289

SUBJECT: Revised Standard Technical Specification (2014) for O&MA Projects, Korea, Revision 1

1. The attached revision 1 (dated 30 October 2015) to the Standard Technical Specifications for O&MA Projects, Korea, previous version dated 24 January 2014, will be applicable to all O&MA funded construction contracts prepared for Area III projects by Directorate of Public Works (DPW), U.S. Army Garrison – Humphreys, unless explicitly indicated otherwise in an individual contract, delivery order or task order.

2. The electronic version of the specifications is in an Acrobat PDF format and can be read with the Acrobat Reader software. In addition, request that the specifications be made available on the 411th CSB-Korea's web page at the same location as the previous version (2014) of the O&MA specifications, http://www.usfk.mil/Resources/ContractingwithUSFK.aspx.

3. Individual construction packages will list the specific specifications that apply to that contract, delivery order or task order. Clarifications and/or supplementation of these specifications will be included in each project's contract package. Additionally, when necessary, revisions and/or changes to the standard technical specifications will be included in a project contract package and take precedence over the content of these specifications.

4. Comments, suggested changes, proposed additions, and improvements should be forwarded to Mr. Yi, Yong Sop, yongsop.yi.ln@mail.mil, (DSN 753-5538), Chief of Design Branch, Engineering Services Division, DPW, USAG Humphreys.

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Thomas A. Kall
Acting Chief, Engineering Services Division
DPW, USAG Humphreys

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, UNITED STATES ARMY GARRISON DAEGU
UNIT #15746
APO AP 96218-5746

IMDA-PWF 9 November 2015

MEMORANDUM FOR Chief, Construction and Supply Division, 411th Contracting Support Brigade, Korea, ATTN: CCEC-KOY-CB, Unit #15289, APO AP 96205-5289

SUBJECT: Revised Standard Technical Specification (2014) for O&MA Projects, Korea, Revision 1

1. The attached revision 1 (dated 30 October 2015) to the Standard Technical Specifications for O&MA Projects, Korea, previous version dated 24 January 2014, will be applicable to all O&MA funded construction contracts prepared for Area IV projects by Directorate of Public Works (DPW), U.S. Army Garrison – Daegu, unless explicitly indicated otherwise in an individual contract, delivery order or task order.

2. The electronic version of the specifications is in an Acrobat PDF format and can be read with the Acrobat Reader software. In addition, request that the specifications be made available on the 411th CSB-Korea's web page at the same location as the previous version (2014) of the O&MA specifications, http://www.usfk.mil/Resources/ContractingwithUSFK.aspx.

3. Individual construction packages will list the specific specifications that apply to that contract, delivery order or task order. Clarifications and/or supplementation of these specifications will be included in each project's contract package. Additionally, when necessary, revisions and/or changes to the standard technical specifications will be included in a project contract package and take precedence over the content of these specifications.

4. Comments, suggested changes, proposed additions, improvements should be forwarded to the undersigned, chon.y.kim.civ@mail.mil, (DSN 764-7541), Chief of Engineering Services Division, Directorate of Public Works, U.S. Army Garrison Daegu.

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CHON Y. KIM
Engineering Division, DPW
USAG Daegu

NOTE: THIS LIST OF REVISIONS IS ONLY MEANT TO INDICATE WHAT GOVERNMENT CONSIDERS SIGNIFICANT CHANGES FROM PREVIOUS VERSION OF THE 2014 O&MA SPECIFICATIONS. ADDITIONALLY, IT IS MEANT ONLY AS A GUIDELINE AND CONTRACTORS ARE RESPONSIBLE FOR ENSURING THEY COMPLY WITH ALL APPLICABLE PROVISIONS OF THESE SPECIFICATIONS, INCLUDING CHANGED PROVISIONS NOT INDICATED ON THIS LIST.

SECTION NUMBER	SECTION TITLE	LOCATION OF CHANGES (PARAGRAPH NUMBERS)
01 30 00	ADMINISTRATIVE REQUIREMENTS	N/A
01 32 01.00 10	PROJECT SCHEDULE	CHANGES (1.1, 1.2, 3.2.2.3, 3.3.4.1, 3.4, 3.4.3, 3.5.1, 3.5.2, 3.5.4.2, 3.6)
01 33 00	SUBMITTAL PROCEDURES	CHANGES (1.8, 1.8.1, 1.8.2, 1.8.3)
01 33 29	LEED(TM) DOCUMENTATION	SECTION ADDITION
01 35 26	GOVERNMENTAL SAFETY REQUIREMENTS	CHANGES (1.1)
01 35 29.13	HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES	CHANGES (1.9.1.2, 1.9.2.2)
01 42 00	SOURCES FOR REFERENCE PUBLICATIONS	CHANGES (1.1, 1.2)
01 45 00.00 10	QUALITY CONTROL	CHANGES (3.4.1)
01 50 00	TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS	CHANGES (1.20
01 57 20.00 10	ENVIRONMENTAL PROTECTION	CHANGES (1.1)
01 58 00	PROJECT IDENTIFICATION	N/A
01 74 19	CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT	SECTION ADDITION
01 78 00	CLOSEOUT SUBMITTALS	N/A
01 78 23	OPERATION AND MAINTENANCE DATA	N/A
02 41 00	DEMOLITION AND DECONSTRUCTION	N/A
02 61 13	EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL	CHANGES (1.1, 1.2.2, 2.2, 3.4.1, 3.5, 3.6.1, 3.6.3, 3.7.1, 3.7.2, 3.7.3, 3.8, 3.9.2, 3.10, 3.11)
02 65 00	UNDERGROUND STORAGE TANK REMOVAL	N/A
02 81 00	TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS	N/A
02 82 14.00 10	ASBESTOS HAZARD CONTROL ACTIVITIES	N/A
02 83 19.00 10	LEAD BASED PAINT HAZARD ABETMENT, TARGET HOUSING & CHILD OCCUPIED FACILITIES	CHANGES (1.1)
03 11 13.00 10	STRUCTURAL CAST-IN-PLACE CONCRETE FORMING	CHANGES (1.1)
03 15 00.00 10	CONCRETE ACCESSORIES	CHANGES (1.1)
03 20 00.00 10	CONCRETE REINFORCING	CHANGES (1.1)
03 30 00	CAST-IN-PLACE CONCRETE	CHANGES (1.1)
03 30 53	MISCELLANEOUS CAST-IN-PLACE CONCRETE	CHANGES (1.2)
03 40 00.00 10	PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION	CHANGES (1.1,)
03 41 16.08	PRECAST CONCRETE SLABS (MAX. SPAN 8'- - 0" O.C.)	CHANGES (1.1)
04 20 00	MASONRY	CHANGES (1.1)
05 05 23	WELDING, STRUCTURAL	CHANGES (1.1)
05 12 00	STRUCTURAL STEEL	CHANGES (1.1, 2.2.1.2)
05 21 23	STEEL JOIST GIRDER FRAMING	CHANGES (1.1)
05 30 00	STEEL DECKS	CHANGES (1.1)
05 50 13	MISCELLANEOUS METAL FABRICATIONS	CHANGES (1.1,
05 50 14	STRUCTURAL METAL FABRICATIONS	CHANGES (1.1, 3.3.1)
05 51 00	METAL STAIRS	CHANGES (1.1)
05 51 33	METAL LADDERS	CHANGES (1.1)
05 52 00	METAL RAILINGS	CHANGES (1.1)
06 10 00	ROUGH CARPENTRY	CHANGES (1.1,
06 20 00	FINISH CARPENTRY	CHANGES (1.1)
07 11 13	BITUMINOUS DAMPPROOFING	N/A
07 12 00	BUILT-UP BITUMINOUS WATERPROOFING	N/A
07 13 53	ELASTOMERIC SHEET WATERPROOFING	CHANGES (1.1)
07 14 00	FLUID-APPLIED WATERPROOFING	CHANGES (1.1)
07 21 13	BOARD AND BLOCK INSULATION	CHANGES (1.1)
07 21 16	MINERAL FIBER BLANKET INSULATION	CHANGES (1.1)
07 22 00	ROOF AND DECK INSULATION	CHANGES (1.1)
07 24 00	EXTERIOR INSULATION AND FINISH SYSTEMS	CHANGES (1.1, 1.2.2.3, 1.2.3.6)
07 31 13	ASPHALT SHINGLES	N/A
07 32 13	ROOF TILES	CHANGES (1.1)
07 41 13	METAL ROOF PANELS	CHANGES (1.1)
07 42 13	METAL WALL PANELS	CHANGES (1.1)
07 51 13	BUILT-UP ASPHALT ROOFING	CHANGES (1.1, 1.2.2.3, 1.2.3.6)
07 53 23	ETHYLENE-PROPYLENE-DIENE-MONOMER ROOFING	CHANGES (1.1)
07 60 00	FLASHING AND SHEET METAL	CHANGES (1.1)
07 61 14.00 20	STEEL STANDING SEAM ROOFING	SECTION ADDITION
07 72 00	ROOF VENTILATORS, GRAVITY, TYPE	SECTION ADDITION
07 81 00	SPRAY-APPLIED FIREPROOFING	CHANGES (1.1)
07 84 00	FIRESTOPPING	CHANGES (1.1)
07 92 00	JOINT SEALANTS	CHANGES (1.1)

SECTION NUMBER	SECTION TITLE	LOCATION OF CHANGES (PARAGRAPH NUMBERS)
08 11 13	STEEL DOORS AND FRAMES	CHANGES (1.1)
08 11 16	ALUMINUM DOORS AND FRAMES	CHANGES (1.1)
08 14 00	WOOD DOORS	CHANGES (1.1)
08 33 13	METAL ROLLING COUNTER DOORS	CHANGES (1.1)
08 33 23	OVERHEAD COILING DOORS	CHANGES (1.1)
08 36 13	SECTIONAL OVERHEAD DOORS	CHANGES (1.1)
08 51 13	ALUMINUM WINDOWS	CHANGES (1.1)
08 52 00	WOOD WINDOWS	CHANGES (1.1)
08 71 00	DOOR HARDWARE	CHANGES (1.1)
08 81 00	GLAZING	CHANGES (1.1)
08 87 16	FRAGMENT RETENTION FILM FOR GLASS	CHANGES (1.1)
08 91 00	METAL WALL AND DOOR LOUVERS	CHANGES (1.1)
09 22 00	SUPPORTS FOR PLASTER AND GYPSUM BOARD	CHANGES (1.1)
09 22 36	LATH	N/A
09 24 23	STUCCO	CHANGES (1.1)
09 29 00	GYPSUM BOARD	CHANGES (1.1)
09 30 00	CERAMIC TILE, QUARRY TILE, AND PAVER TILE	CHANGES (1.1)
09 51 00	ACOUSTICAL CEILINGS	CHANGES (1.1)
09 64 29	WOOD STRIP FLOORING	CHANGES (1.1)
09 64 66	WOOD ATHLETIC FLOORING	SECTION ADDITION
09 65 00	RESILIENT FLOORING	N/A
09 65 66	RESILIENT ATHLETIC FLOORING	CHANGES (1.1)
09 68 00	CARPET	CHANGES (1.1)
09 69 13	RIGID GRID ACCESS FLOORING	CHANGES (1.1)
09 69 19	STRINGERLESS ACCESS FLOORING	CHANGES (1.1)
09 72 00	WALLCOVERINGS	CHANGES (1.1)
09 83 13	ACOUSTICAL WALL TREATMENT	SECTION ADDITION
09 90 00	PAINTS AND COATINGS	CHANGES (1.1)
10 14 01	EXTERIOR SIGNAGE	N/A
10 14 02	INTERIOR SIGNAGE	CHANGES (1.1)
10 21 13	TOILET COMPARTMENTS	CHANGES (1.1)
10 26 13	WALL AND CORNER GUARDS	SECTION ADDITION
10 28 13	TOILET ACCESSORIES	N/A
11 68 13	PLAYGROUND EQUIPMENT	CHANGES (1.1)
12 21 00	WINDOW BLINDS	N/A
12 32 00	MANUFACTURED WOOD CASEWORK	CHANGES (1.1)
12 36 00	COUNTERTOPS	CHANGES (1.1)
13 48 00.00 10	SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT	CHANGES (1.1)
13 48 00	SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT	CHANGES (1.1)
21 13 13.00 00	WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION	CHANGES (1.1, 2.11.1,
21 13 17.00 10	DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION	CHANGES (1.1, 2.5.4.2, 2.12.1)
21 13 18.00 10	PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION	CHANGES (1.1, 2.5.4.3, 2.11.1)
21 13 24.00 10	AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM	CHANGES (1.1)
21 21 03.00 10	WET CHEMICAL FIRE EXTINGUISHING SYSTEM	CHANGES (1.1)
21 30 00	FIRE PUMPS	CHANGES (1.1, 2.5.3, 2.14)
22 00 00	PLUMBING, GENERAL PURPOSE	CHANGES (1.1, 2.4.3, 2.4.4, 2.4.5, 2.4.7, 2.4.9, 2.4.10, 2.4.11, 2.10.1.4, 2.14, 2.15, 2.16, 2.17, 2.17.1, 2.17.2, 2.17.2.1, 2.17.2.2, 2.17.3, 2.17.4, 2.17.5, 3.1.2, 3.1.2.1, 3.1.2.2, 3.1.2.3, 3.1.2.4, 3.1.2.5, 3.1.2.6, 3.1.2.7, 3.1.2.8, 3.1.2.9, 3.1.2.10, 3.1.3, 3.1.4, 3.1.5, 3.1.5.1, 3.1.5.2, 3.1.5.3, 3.1.5.4, 3.1.5.5, 3.1.5.6, 3.1.6, 3.1.7., 3.1.7.1, 3.1.7.2, 3.1.7.3, 3.1.7.4, 3.1.8, 3.1.9, 3.5, 3.9.2, 3.9.5, 3.130)
22 31 00	WATER SOFTENERS, CATION-EXCHANGES (SODIUM CYCLE)	CHANGES (1.1, 2.7.4)
23 00 00	AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS	CHANGES (1.1, 1.4.7, 2.11.2.4, 2.12.3, 2.12.3.6, 3.9)
23 03 00.00 20	BASIC MECHANICAL MATERIALS AND METHODS	CHANGES (1.1, 1.4.5.3)
23 05 93	TESTING, ADJUSTING, AND BALANCING FOR HVAC	CHANGES (1.1, 1.3, 1.5.5.1, 3.3.4, 3.4.5.4)
23 07 00	THERMAL INSULATION FOR MECHANICAL SYSTEMS	CHANGES (1.1, 2.3.1, 2.3.3, 2.4, 2.4.1.2, 2.4.3.2, 2.4.5, 3.2.1.5, 3.2.1.6)
23 08 00.00 10	COMMISSIONING OF HVAC SYSTEMS	N/A
23 09 23.13 20	BACnet DIRECT DIGITAL CONTROL FOR HVAC	CHANGES (1.1, 1.2.32)
23 09 23	LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS	CHANGES (1.1, 1.2, 1.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.14.1, 3.2.4, 3.9.2, APPENDIX A)
23 09 53.00 20	SPACE TEMPERATURE CONTROL SYSTEMS	CHANGES (1.1, 2.18.1.1)

SECTION NUMBER	SECTION TITLE	LOCATION OF CHANGES (PARAGRAPH NUMBERS)
23 11 25	FACILITY GAS PIPING	CHANGES (1.1, 2.2.4, 2.2.7)
23 23 00	REFRIGERANT PIPING	CHANGES (1.1, 2.4.3, 2.6.10
23 52 00	HEATING BOILERS	CHANGES (1.1, 2.12.13.2, 3.4, 3.5.3, 3.6)
23 57 10.00 10	FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS	CHANGES (1.1, 2.2.10, 2.10.10
23 63 00.00 10	COLD STORAGE REFRIGERATION SYSTEMS	CHANGES (1.1, 2.21.4)
23 64 00	PACKAGED WATER CHILLERS, ABSORPTION TYPE	CHANGES (1.1)
23 64 10	WATER CHILLERS, VAPOR COMPRESSION TYPE	CHANGES (1.1)
23 64 26	CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS	CHANGES (1.1, 2.3.1, 2.5.2, 2.6.16)
23 65 00	COOLING TOWERS	CHANGES (1.1)
23 82 01.00 10	WARM AIR HEATING SYSTEMS	CHANGES (1.1, 3.6.1)
23 82 02.00 10	UNITARY HEATING AND COOLING EQUIPMENT	CHANGES (1.1)
25 08 10	UTILITY MONITORING AND CONTROL SYSTEM TESTING	CHANGES (1.1, 1.2.17, 1.2.26, 3.8)
25 10 10	LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS)	CHANGES (1.1, 1.2, 1.3, 1.3.1, 2.1.1, 2.2.2.1, 2.4.4, 2.4.5, 2.4.6.2, 3.3.3, 3.5.1, 3.5.2, 3.5.4.2, 3.6.2, 3.6.3, 3.10.3, APPENDIX A)
26 00 00.00 20	BASIC ELECTRICAL MATERIALS AND METHODS	N/A
26 05 48.00 10	SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT	CHANGES (1.1)
26 08 00	APPARATUS INSPECTION AND TESTING	CHANGES (1.1)
26 20 00	INTERIOR DISTRIBUTION SYSTEM	CHANGES (2.9.4.1, 2.9.4.2, 2.13.1, 2.27.3, 2.28, 3.1.8, 3.1.18)
26 23 00	SWITCHBOARDS AND SWITCHGEAR	CHANGES (1.1)
26 28 01.00 10	COORDINATED POWER SYSTEM PROTECTION	CHANGES (1.1, 1.6)
26 32 14.00 10	DIESEL-GENERATOR SET, STATIONARY 15-300 KW, STANDBY APPLICATIONS	CHANGES (1.1)
26 36 00.00 10	AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH	CHANGES (1.1)
26 41 00	LIGHTNING PROTECTION SYSTEM	SECTION ADDITION
26 42 14.00 10	CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE)	CHANGES (1.1, 1.2)
26 42 17.00 10	CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT)	CHANGES (1.1, 1.2)
26 51 00	INTERIOR LIGHTING	CHANGES (1.1, 2.1.1, 2.1.2, 2.13.5)
26 56 00	EXTERIOR LIGHTING	UPDATED WITH MOST CURRENT VERSION OF THIS SECTION FROM UFGS
26 56 20.00 10	AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS	SECTION ADDITION
27 10 00	BUILDING TELECOMMUNICATIONS CABLING SYSTEM	CHANGES (1.1, 2.4.2, 2.4.5.1, 2.4.5.2, 2.4.6)
27 54 00.00 20	COMMUNITY ANTENNA TELEVISION (CATV) SYSTEMS	N/A
28 31 33.00 10	FIRE ALARM REPORTING SYSTEM, RADIO TYPE	CHANGES (1.1)
28 31 49	CARBON MONOXIDE DETECTORS	SECTION ADDITION
28 31 64.00 10	FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE	CHANGES (1.1)
28 31 76	INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM	CHANGES (1.1)
31 00 00	EARTHWORK	CHANGES (1.1)
31 11 00	CLEARING AND GRUBBING	CHANGES (1.1)
31 36 00	WIRE MESH GABIONS	CHANGES (1.1)
32 01 11.51	RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS	SECTION ADDITION
32 01 16.17	COLD MILLING OF BITUMINOUS PAVEMENTS	SECTION ADDITION
32 01 17.16	SEALING OF CRACKS IN BITUMINOUS PAVEMENTS	SECTION ADDITION
32 01 19.61	RESEALING OF JOINTS IN RIGID PAVEMENT	SECTION ADDITION
32 01 19	FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS	CHANGES (1.1)
32 01 26.71	GROOVING FOR AIRFIELD PAVEMENTS	SECTION ADDITION
32 01 29.61	PARTIAL DEPTH PATCHING OF RIGID PAVING	SECTION ADDITION
32 05 33	LANDSCAPE ESTABLISHMENT	N/A
32 11 10	DRAINAGE LAYER	SECTION ADDITION
32 11 16.16	BASE COURSE FOR RIGID AND SUBBASE COURSE FOR FLEXIBLE PAVING	CHANGES (SECTION NAME, DATE, 1.1)
32 11 16	SUBBASES FOR FLEXIBLE PAVING	CHANGES (SECTION NAME, DATE, 1.1,
32 11 23	AGGREGATE AND/OR GRADED-CRUSHED AGGREGATE BASE COURSE	CHANGES (1.1)
32 11 24	GRADED CRUSHED AGGREGATE BASE COURSE FOR PERVIOUS PAVEMENT	CHANGES (SECTION NAME, DATE, 1.1)
32 12 10	BITUMINOUS TACK AND PRIME COATS	CHANGES (1.1)
32 12 11	BITUMINOUS SURFACE TREATMENT	CHANGES (1.1)
32 12 15.13	HOT-MIX ASPHALT AIRFIELD PAVING	SECTION ADDITION
32 12 16	HOT-MIX ASPHALT (HMA) FOR ROADS	CHANGES (1.1, 1.3)
32 12 37	FUEL-RESISTANT (COAL TAR) SEALER	CHANGES (1.1)
32 13 11	CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS	SECTION ADDITION
32 13 13.06	PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES	CHANGES (1.1)
32 13 73	COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS	N/A
32 15 00	AGGREGATE SURFACE COURSE	CHANGES (1.1, 1.2)
32 16 13	CONCRETE SIDEWALKS AND CURBS AND GUTTERS	CHANGES (1.1)
32 17 24.00 10	PAVEMENT MARKINGS	N/A
32 18 16.13	PLAYGROUND PROTECTIVE SURFACING	CHANGES (1.1)

SECTION NUMBER	SECTION TITLE	LOCATION OF CHANGES (PARAGRAPH NUMBERS)
32 31 13.53	HIGH-SECURITY CHAIN LINK FENCES AND GATES	CHANGES (1.1)
32 31 13	CHAIN LINK FENCES AND GATES	CHANGES (1.1)
32 84 23	UNDERGROUND SPRINKLER SYSTEMS	CHANGES (1.1)
32 84 24	IRRIGATION SPRINKLER SYSTEMS	CHANGES (1.1)
32 92 19	SEEDING	CHANGES (1.1)
32 92 23	SODDING	CHANGES (1.1)
32 93 00	EXTERIOR PLANTS	CHANGES (1.1)
32 96 00	TRANSPLANTING EXTERIOR PLANTS	CHANGES (1.1)
33 08 55	COMMISSIONING OF FUEL FACILITY SYSTEMS	N/A
33 11 00	WATER DISTRIBUTION	CHANGES (1.1)
33 30 00	SANITARY SEWERS	CHANGES (1.1)
33 34 00	FORCE MAINS AND INVERTED SIPHONS; SEWER	CHANGES (1.1)
33 40 00	STORM DRAINAGE UTILITIES	CHANGES (1.1)
33 46 16	SUBDRAINAGE SYSTEM	CHANGES (1.1)
33 51 15	NATURAL-GAS/LIQUID PETROLEUM GAS DISTRIBUTION	CHANGES (1.1)
33 56 10	FACTORY-FABRICATED FUEL STORAGE TANKS	CHANGES (1.2)
33 58 00	LEAK DETECTION FOR FUELING SYSTEMS	CHANGES (1.1)
33 70 02.00 10	ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND	CHANGES (1.1, 1.2, 1.3, 1.4.1, 3.9)
33 71 01	OVERHEAD TRANSMISSION AND DISTRIBUTION	CHANGES (1.1)
33 82 00	TELECOMMUNICATIONS OUTSIDE PLANT (OSP)	CHANGES (1.1)
34 71 13.19	ACTIVE VEHICLE BARRIERS	CHANGES (1.1)
34 71 13.26 31	VEHICLE GUARDRAIL	SECTION ADDITION
34 73 13	MOORING AND GROUNDING POINTS FOR AIRCRAFT	SECTION ADDITION
40 05 13.96	WELDING PROCESS PIPING	CHANGES (1.1, 1.4)

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SECTION 01 30 00

ADMINISTRATIVE REQUIREMENTS
11/11

PART 1 GENERAL

1.1 CONTRACTING OFFICER

Any references to the Contracting Officer (KO) throughout all sections of these specifications shall be interpreted to mean the Procuring or Administrative Contracting Officer of record, and his or her designated representative, usually the appointed Contracting Officer Representative (COR).

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

View location map; G

Progress and completion pictures

1.3 APPLICABILITY

If these specifications are incorporated by reference in a contract or task order, then each specific section will apply to any relevant work in the contract. An individual contract or task order may explicitly refer to a particular section for guidance, but those references will not limit the general application of the specifications.

When necessary, clarifications, supplementation, and/or revisions to the standard technical specifications may be included in a contract or task order and will take precedence over the relevant sections of these specifications.

1.4 VIEW LOCATION MAP

Submit to the Contracting Officer, prior to or with the first digital photograph submittals, a sketch or drawing indicating the required photographic locations. Update as required if the locations are moved.

1.5 PROGRESS AND COMPLETION PICTURES

Photographically document site conditions prior to start of construction operations. Provide monthly, and within one month of the completion of work, digital photographs, 1600x1200x24 bit true color, 8 megapixel minimum resolution in JPEG file format showing the sequence and progress of work. Take a minimum of 20 digital photographs each week throughout the entire project from a minimum of ten views from points located by the Contracting Officer. Submit a view location sketch indicating points of view. Submit with the monthly invoice two sets of digital photographs each set on a separate CD-R, cumulative of all photos to date. Indicate photographs demonstrating environmental procedures. Photographs for each month shall be in a separate monthly directory and each file shall be named to indicate its location on the view location sketch. The view location sketch shall also be provided on the CD as digital file. All file names shall include a date designator. Cross reference submittals in the appropriate daily report. Photographs shall be provided for unrestricted use by the Government.

1.6 MINIMUM INSURANCE REQUIREMENTS

Procure and maintain during the entire period of performance under this contract the following minimum insurance coverage:

a. Comprehensive general liability: 500,000,000 WON per occurrence

b. Automobile liability: 200,000,000 WON per person, 500,000,000 WON per occurrence for bodily injury, 50,000,000 WON per occurrence for property damage

1.7 CONTRACTOR SPECIAL REQUIREMENTS

1.7.1 Asbestos Containing Material

All contract requirements of Section 02 82 14.00 10 ASBESTOS HAZARD CONTROL ACTIVITIES shall be accomplished directly by no lower than a first tier subcontractor.

1.7.2 Space Temperature Control, HVAC TAB, and Apparatus Inspection

All contract requirements of Section Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC, and Section 26 08 00 APPARATUS INSPECTION AND TESTING shall be accomplished directly by a first tier subcontractor, including the Commissioning Agent. No work required by Section 23 09 23, 23 05 93, or 26 08 00 shall be accomplished by a second tier subcontractor.

1.8 SUPERVISION

Have at least one qualified supervisor capable of reading, writing, and conversing fluently in the English language on the job site during working hours.

1.9 PRECONSTRUCTION CONFERENCE

After award of the contract but prior to commencement of any work at the site, meet with the Contracting Officer to discuss and develop a mutual understanding relative to the administration of the value engineering and safety program, preparation of the schedule of prices or earned value report, shop drawings, and other submittals, scheduling programming, prosecution of the work, and clear expectations of the "Interim DD Form 1354" Submittal.

1.10 AVAILABILITY OF CADD DRAWING FILES

After award and upon request, the electronic "Computer-Aided Drafting and

Design (CADD)" drawing files will only be made available to the Contractor for use in preparation of construction data related to the referenced contract subject to the following terms and conditions.

Data contained on these electronic files shall not be used for any purpose other than as a convenience in the preparation of construction data for the referenced project. Any other use or reuse shall be at the sole risk of the Contractor and without liability or legal exposure to the Government. The Contractor shall make no claim and waives to the fullest extent permitted by law, any claim or cause of action of any nature against the Government, its agents or sub consultants that may arise out of or in connection with the use of these electronic files. The Contractor shall, to the fullest extent permitted by law, indemnify and hold the Government harmless against all damages, liabilities or costs, including reasonable attorney's fees and defense costs, arising out of or resulting from the use of these electronic files.

These electronic CADD drawing files are not construction documents. Differences may exist between the CADD files and the corresponding construction documents. The Government makes no representation regarding the accuracy or completeness of the electronic CADD files, nor does it make representation to the compatibility of these files with the Contractors hardware or software. In the event that a conflict arises between the signed and sealed construction documents prepared by the Government and the furnished CADD files, the signed and sealed construction documents shall govern. The Contractor is responsible for determining if any conflict exists. Use of these CADD files does not relieve the Contractor of duty to fully comply with the contract documents, including and without limitation, the need to check, confirm and coordinate the work of all contractors for the project.

If the Contractor uses, duplicates and/or modifies these electronic CADD files for use in producing construction drawings and data related to this contract, all previous indicators of ownership (seals, logos, signatures, initials and dates) shall be removed.

1.11 ELECTRONIC MAIL (E-MAIL) ADDRESS

The Contractor shall establish and maintain electronic mail (e-mail) capability along with the capability to open various electronic attachments in Microsoft, Adobe Acrobat, and other similar formats. Within 10 days after contract award, the Contractor shall provide the Contracting Officer a single (only one) e-mail address for electronic communications from the Contracting Officer related to this contract including, but not limited to contract documents, invoice information, request for proposals, and other correspondence. The Contracting Officer may also use e-mail to notify the Contractor of base access conditions when emergency conditions warrant, such as hurricanes, terrorist threats, etc. Multiple e-mail address will not be allowed.

It is the Contractor's responsibility to make timely distribution of all Contracting Officer initiated e-mail with its own organization including field office(s). The Contractor shall promptly notify the Contracting Officer, in writing, of any changes to this e-mail address.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 01 32 01.00 10

PROJECT SCHEDULE

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Preliminary Project Schedule; G

Initial Project Schedule; G

Periodic Schedule Updates; G

Schedule Status Report; G

1.2 QUALITY ASSURANCE

Designate an authorized representative to be responsible for the preparation of the schedule and all required updating (activity status) and preparation of reports. The authorized representative shall have previously developed, created, and reviewed computerized schedules.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Prepare for approval a Project Schedule, as specified herein, pursuant to the Contract Clause, SCHEDULE FOR CONSTRUCTION CONTRACTS. Show in the schedule the sequence in which the Contractor proposes to perform the work and dates on which the Contractor contemplates starting and completing all schedule activities. The scheduling of the entire project, including the design and construction sequences, is required. The scheduling of construction is the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule. Provide a schedule that is a forward planning as well as a project monitoring tool. The Project Schedule shall be approved by the Contracting Officer and shall be used to measure the progress of the work, to aid in evaluating time extensions, and to provide the basis of all progress payments.

3.1.1 Approved Project Schedule

Use the approved Project Schedule to measure the progress of the work and to aid in evaluating time extensions. Make the schedule cost loaded and activity coded. The schedule will provide the basis for all progress payments. If the Contractor fails to submit any schedule within the time prescribed, the Contracting Officer may withhold approval of progress payments until the Contractor submits the required schedule.

3.1.2 Schedule Status Reports

Provide a Schedule Status Report on at least a monthly basis. If, in the opinion of the Contracting Officer, the Contractor falls behind the approved schedule, take steps necessary to improve its progress including those that may be required by the Contracting Officer, without additional cost to the Government. In this circumstance, the Contracting Officer may require the Contractor to increase the number of shifts, overtime operations, days of work, and/or the amount of construction plant, and to submit for approval any supplementary schedule or schedules as the Contracting Officer deems necessary to demonstrate how the approved rate of progress will be regained.

3.1.3 Default Terms

Failure of the Contractor to comply with the requirements of the Contracting Officer shall be grounds for a determination, by the Contracting Officer, that the Contractor is not prosecuting the work with sufficient diligence to ensure completion within the time specified in the contract. Upon making this determination, the Contracting Officer may terminate the Contractor's right to proceed with the work, or any separable part of it, in accordance with the default terms of the contract.

3.2 BASIS FOR PAYMENT AND COST LOADING

Use the schedule as the basis for determining contract earnings during each update period and therefore the amount of each progress payment. Lack of an approved schedule update will result in the inability of the Contracting Officer to evaluate contract earned value for the purposes of payment. Failure of the Contractor to provide all required information will result in the disapproval of the preliminary, initial and subsequent schedule updates. In the event schedule revisions are directed by the Contracting Officer and those revisions have not been included in subsequent revisions or updates, the Contracting Officer may retain up to the maximum allowed by contract, each payment period, until such revisions to the Project Schedule have been made. Activity cost loading shall be reasonable, as determined by the Contracting Officer. The aggregate value of all activities coded to a Contract Line Item Number (CLIN) shall equal the value of the CLIN on the Schedule.

3.3 PROJECT SCHEDULE DETAILED REQUIREMENTS

The computer software system utilized to produce and update the Project Schedule shall be capable of meeting all the requirements of this specification. Failure of the Contractor to meet the requirements of this specification will result in the disapproval of the schedule.

3.3.1 Critical Path Method

Use the Critical Path Method (CPM) of network calculation to generate the

Project Schedule. Prepare the Project Schedule using the Precedence Diagram Method (PDM).

3.3.2 Level of Detail Required

Develop the Project Schedule to an appropriate level of detail. Failure to develop the Project Schedule to an appropriate level of detail, as determined by the Contracting Officer, will result in its disapproval. The Contracting Officer will consider, but is not limited to, the following characteristics and requirements to determine appropriate level of detail:

3.3.2.1 Activity Durations

Activity durations are those that allow the progress of ongoing activities to be accurately determined between update periods. Less than 2 percent of all non-procurement activities shall have Original Durations greater than 20 work days or 30 calendar days. Procurement activities are defined herein.

3.3.2.2 Procurement Activities

The schedule must include activities associated with the submittal, approval, procurement, fabrication and delivery of long lead materials, equipment, fabricated assemblies and supplies. Long lead procurement activities are those with an anticipated procurement sequence of over 90 calendar days. A typical procurement sequence includes the string of activities: submit, approve, procure, fabricate, and deliver.

3.3.2.3 Mandatory Tasks and Critical Activities

The following tasks must be included and listed as separate line activities on the project schedule:

a. Submission, review, and acceptance of design packages.

b. Submission of mechanical/electrical/information systems layout drawings.

c. Submission and approval of O & M manuals.

d. Submission and approval of as-built drawings.

e. Submission and approval of 1354 data and installed equipment lists.

f. Submission and approval of testing and air balance (TAB).

g. Submission of TAB specialist design review report.

h. Submission and approval of fire protection specialist.

i. Submission and approval of testing and balancing of HVAC plus commissioning plans and data. Develop the schedule logic associated with testing and commissioning of mechanical systems to a level of detail consistent with 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

j. Air and water balancing.

k. HVAC commissioning.

l. Controls testing plan submission.

m. Controls testing.

n. Performance Verification testing.

o. Other systems testing, if required.

p. Contractor's pre-final inspection.

q. Correction of punch list from Contractor's pre-final inspection.

r. Government's pre-final inspection.

s. Correction of punch list from Government's pre-final inspection.

t. Final inspection.

u. Planned utility outages.

3.3.2.4 Government Activities

Show Government and other agency activities that could impact progress. These activities include, but are not limited to: approvals, inspections, utility tie-in, Government Furnished Equipment (GFE), security operations, and Notice to Proceed (NTP) for phasing requirements.

3.3.2.5 Activity Responsibility Coding

Assign responsibility Code for all activities to the Prime Contractor, Subcontractor or Government agency responsible for performing the activity. Activities coded with a Government Responsibility code include, but are not limited to: Government approvals, Government design reviews, environmental permit approvals by Contracting Officer, Government Furnished Equipment (GFE) and Notice to Proceed (NTP) for phasing requirements. Code all activities not coded with a Government Responsibility Code to the Prime Contractor or Subcontractor responsible to perform the work. Activities shall not have more than one Responsibility Code. Examples of acceptable activity code values are: DOR (for the designer of record); ELEC (for the electrical subcontractor); MECH (for the mechanical subcontractor); and GOVT (for Government). Unacceptable code values are abbreviations of the names of subcontractors.

3.3.2.6 Activity Work Area Coding

Assign Work Area code to activities based upon the work area in which the activity occurs. Define work areas based on resource constraints or space constraints that would preclude a resource, such as a particular trade or craft work crew, from working in more than one work area at a time due to restraints on resources or space. Examples of Work Area Coding include different areas within a floor of a building, different floors within a building, and different buildings within a complex of buildings. Activities shall not have more than one Work Area Code. Not all activities are required to be Work Area coded. A lack of Work Area coding will indicate the activity is not resource or space constrained.

3.3.2.7 Contract Changes (MODF)

Assign Activity code to any activity or sequence of activities added to the schedule as a result of a Contract Modification, when approved by the Contracting Officer, with a Contract Changes/MODF Code. Key all Code values to the Government's modification numbering system. Any activity or sequence of activities added to the schedule as a result of alleged constructive changes made by the Government may be added to a copy of the current schedule, subject to the approval of the Contracting Officer. Assign Activity codes for these activities with a Contract Changes/REA Code. Key the code values to the Contractor's numbering system. Approval to add these activities does not necessarily mean the Government accepts responsibility and, therefore, liability for such activities and any associated impacts to the schedule, but rather the Government recognizes such activities are appropriately added to the schedule for the purposes of maintaining a realistic and meaningful schedule. Such activities shall not be Responsibility Coded to the Government unless approved. An activity shall not have more than one Contract Changes/MODF Code.

3.3.2.8 Contract Line Item (CLIN) Coding

Code all activities to the CLIN on the Contract Line Item Schedule to which the activity belongs. An activity shall not contain more than one CLIN Item Code. CLIN Item code all activities, even when an activity is not cost loaded.

3.3.2.9 Phase of Work Coding

Assign Phase of Work Code to all activities based upon the phase of work in which the activity occurs. Code activities to a Construction Phase. Code fast track construction phases proposed by the Contractor to allow filtering and organizing the schedule by fast track design and construction packages. If the contract specifies construction phasing with separately defined performance periods, identify a Construction Phase Code to allow filtering and organizing the schedule accordingly. Each activity shall be identified with a single project phase and have only one Phase of Work code.

3.3.2.10 Category of Work Coding

Assign Category of Work Code to all Activities based upon the category of work to which the activity belongs. Category of Work Code must include, but is not limited to: construction submittal approvals, Acceptance, Procurement, Fabrication, Delivery, Weather Sensitive Installation, Non-Weather Sensitive Installation, Start-Up, Test and Turnover. Assign a Category of Work Code to each activity. Each activity shall have only one Category of Work Code.

3.3.2.11 Definable Features of Work Coding

Assign a Definable Feature of Work Code to appropriate activities based on the definable feature of work to which the activity belongs. Definable Feature of Work is defined in Specification Section 01 45 00.00 10 QUALITY CONTROL. An activity shall not have more than one Definable Feature of Work Code. Not all activities are required to be Definable Feature of Work Coded.

3.3.3 Scheduled Project Completion and Activity Calendars

The schedule interval shall extend from NTP date to the required contract completion date. The contract completion activity (End Project) shall finish based on the required contract duration in the accepted contract proposal, as adjusted for any approved contract time extensions. The first scheduled work period shall be the day after NTP is received by the Contractor. Schedule activities on a calendar to which the activity logically belongs. Activities may be assigned to a 7 day calendar when the contract assigns calendar day durations for the activity such as a Government Acceptance activity. If the Contractor intends to perform physical work less than seven days per week, schedule the associated activities on a calendar with non-work periods identified including weekends and holidays. Assign the Category of Work Code - Weather Sensitive Installation to those activities that are weather sensitive. Original durations must account for anticipated normal adverse weather. The Government will interpret all work periods not identified as non-work periods on each calendar as meaning the Contractor intends to perform work during those periods.

3.3.3.1 Project Start Date

The schedule shall start no earlier than the date on which the NTP was acknowledged. Include as the first activity in the project schedule an activity called "Start Project"(or NTP). The "Start Project" activity shall have a constraint date equal to the date that the NTP was acknowledged, and duration of zero days.

3.3.3.2 Schedule Constraints and Open Ended Logic

Constrain completion of the last activity in the schedule by the contract completion date. Schedule calculations shall result in a negative float when the calculated early finish date of the last activity is later than the contract completion date. Include as the last activity in the project schedule an activity called "End Project". The "End Project" activity shall have a constraint date equal to the contract completion date for the project, and with a zero day duration or by using the "project must finish by" date in the scheduling software. The schedule shall have no constrained dates other than those specified in the contract. The use of artificial float constraints such as "zero fee float" or "zero total float" are typically prohibited. There shall only be 2 open ended activities: Start Project (or NTP) with no predecessor logic and End Project with no successor logic.

3.3.3.3 Early Project Completion

In the event the Preliminary or Initial project schedule calculates an early completion date of the last activity prior to the contract completion date, identify those activities that it intends to accelerate and/or those activities that are scheduled in parallel to support the Contractor's "early" completion. The last activity shall have a late finish constraint equal to the contract completion date and the schedule will calculate positive float. The Government will not approve an early completion schedule with zero float on the longest path. The Government is under no obligation to accelerate activities for which it is responsible to support a proposed early contract completion.

3.3.4 Interim Completion Dates

Constrain contractually specified interim completion dates to show negative float when the calculated early finish date of the last activity in that phase is later than the specified interim completion date.

3.3.5 Default Progress Data Disallowed

Do not automatically update Actual Start and Finish dates with default mechanisms that may be included in the scheduling software. Activity Actual Start and Actual Finish dates assigned during the updating process shall match those dates provided from Contractor Quality Control Reports. Failure of the Contractor to document the Actual Start and Actual Finish dates on the Daily Quality Control report for every in-progress or completed activity, and failure to ensure that the data contained on the Daily Quality Control reports is the sole basis for schedule updating shall result in the disapproval of the Contractor's updated schedule and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. Updating of the percent complete and the remaining duration of any activity shall be independent functions. Disable program features which calculate one of these parameters from the other.

3.3.6 Out-of-Sequence Progress

Activities that have progressed before all preceding logic has been satisfied (Out-of-Sequence Progress) will be allowed only on a case-by-case basis subject to approval by the Contracting Officer. Propose logic corrections to eliminate all out of sequence progress or justify not changing the sequencing for approval prior to submitting an updated project schedule. Correct out of sequence progress that continues for more than two update cycles by logic revision, as approved by the Contracting Officer.

3.3.7 Negative Lags and Start to Finish Relationships

Lag durations contained in the project schedule shall not have a negative value. Do not use Start to Finish relationships.

3.3.8 Calculation Mode

Schedule calculations shall retain the logic between predecessors and successors even when the successor activity starts and the predecessor activity has not finished. Software features that in effect sever the tie between predecessor and successor activities when the successor has started and the predecessor logic is not satisfied ("progress override") will not be allowed.

3.4 PROJECT SCHEDULE SUBMISSIONS

Provide the submissions as described below. The requirements for each submission are contained in paragraph SUBMISSION REQUIREMENTS.

3.4.1 Preliminary Project Schedule Submission

Submit the Preliminary Project Schedule, defining the Contractor's planned operations for the first 90 calendar days for approval within 5 calendar days after the NTP is acknowledged. The approved Preliminary Project Schedule will be used for payment purposes not to exceed 90 calendar days after NTP. Completely cost load the Preliminary Project Schedule to balance the contract award Contract Line Item Numbers (CLIN) shown on the Price Schedule. Detail it for the first 90 calendar days. It may be summary in nature for the remaining performance period. It must be early start and late finish constrained and logically tied as previously specified. The Preliminary Project Schedule forms the basis for the Initial Project Schedule specified herein and must include all of the required Plan and Program preparations, submissions and approvals identified in the contract (for example, Quality Control Plan, Safety Plan, and Environmental Protection Plan), and other non-construction activities intended to occur within the first 90 calendar days. Schedule any construction activities planned for the first 90 calendar days after NTP. Constrain planned construction activities by Government acceptance of specified Program and Plan approvals and any submittals requiring approval in the first thirty days.

3.4.2 Initial Project Schedule Submission

Submit the Initial Project Schedule for approval within 30 calendar days after NTP. The schedule shall demonstrate a reasonable and realistic sequence of activities which represent all work through the entire contract performance period. The Initial Schedule shall be at a reasonable level of detail as determined by the Contracting Officer.

3.4.3 Periodic Schedule Updates

Periodic schedule updates schedules shall be submitted together with the partial progress payment requests or as requested by Contracting Officer Representative. These submissions will enable the Contracting Officer to assess Contractor's progress. If the Contractor fails or refuses to furnish the information and project schedule data, which in the judgment of the Contracting Officer or authorized representative is necessary for verifying the Contractor's progress, the Contractor shall be deemed not to have provided an estimate upon which progress payment may be made.

3.5 SUBMISSION REQUIREMENTS

Submit the following items for the Preliminary Schedule, Initial Schedule, and every Periodic Schedule Update throughout the life of the project:

3.5.1 Data CD's

One digital copy (.pdf) of the schedules showing codes, values, categories, numbers, items, etc., as required. Each schedule shall have a unique file name as determined by the Contractor, unless specific submittal naming instructions are provided by the Government.

3.5.2 Narrative Report

Provide a Narrative Report with the Preliminary, Initial, and each Periodic Update of the project schedule, as the basis of the progress payment request. The Narrative Report shall include: a description of current and anticipated problem areas or delaying factors and their impact and an explanation of corrective actions taken or required to be taken. The narrative report is expected to communicate to the Government, the Contractor's thorough analysis of the schedule output and its plans to compensate for any problems, either current or potential, which are revealed through that analysis. Identify and explain why any activities that, based their calculated late dates, should have either started or finished during the update period but did not.

3.5.3 Approved Changes Verification

Include only those project schedule changes in the schedule submission that have been previously approved by the Contracting Officer. The Narrative Report shall specifically reference, on an activity by activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes.

3.5.4 Schedule Reports

The format, filtering, organizing and sorting for each schedule report shall be as directed by the Contracting Officer. Typically reports shall contain: Activity Numbers, Activity Description, Original Duration, Remaining Duration, Early Start Date, Early Finish Date, Late Start Date, Late Finish Date, Total Float, Actual Start Date, Actual Finish Date, and Percent Complete. The following lists typical reports that will be requested. One or all of these reports may be requested for each schedule submission.

3.5.4.1 Activity Report

A list of all activities sorted according to activity number.

3.5.4.2 Earnings Report by CLIN

A compilation of the Contractor's Total Earnings on the project from the NTP to the data date. This report shall reflect the earnings of specific activities based on the agreements made in the schedule update meeting defined herein. Provided that the Contractor has furnished a complete schedule update, this report shall serve as the basis of determining progress payments. Group activities by CLIN item number and sort by activity number. This report shall: sum all activities coded to a particular CLIN and provide a CLIN item percent earned value; and complete and sum CLIN items to provide a total project percent complete. The printed report shall contain, for each activity: the Activity Number, Activity Description, Original Budgeted Amount, Total Quantity, Quantity to Date, Percent Complete (based on cost), and Earnings to Date.

3.5.5 Network Diagram

The network diagram is required for the Preliminary, Initial and Periodic Updates. The network diagram shall depict and display the order and interdependence of activities and the sequence in which the work is to be accomplished. The Contracting Officer will use, but is not limited to, the following conditions to review compliance with this paragraph:

3.5.5.1 Continuous Flow

Diagrams shall show a continuous flow from left to right with no arrows from right to left. Show the activity number, description, duration, and estimated earned value on the diagram.

3.5.5.2 Project Milestone Dates

Show dates on the diagram for start of project, any contract required interim completion dates, and contract completion dates.

3.5.5.3 Critical Path

Clearly show the critical path.

3.5.5.4 Banding

Organize activities as directed to assist in the understanding of the activity sequence. Typically, this flow will group activities by category of work, work area and/or responsibility.

3.5.5.5 S-Curves

Earnings curves showing projected early and late earnings and earnings to date.

3.6 PERIODIC PROGRESS MEETINGS

Conduct periodic progress meetings for the purposes of reviewing the Contractor's proposed out of sequence corrections, determining causes for delay, correcting logic, maintaining schedule accuracy and determining earned value. Meetings shall occur at regular intervals mutually agreed to at the preconstruction conference. The Contractor's Project Manager shall attend the meeting with the Contracting Officer Representative. During this meeting the Contractor shall describe, on an activity by activity basis, all proposed revisions and adjustments to the project schedule required to reflect the current status of the project. The meeting will be a working interactive exchange which will allow the Government and the Contractor the opportunity to review the updated schedule on a real time and interactive basis.

3.6.1 Update Submission Following Progress Meeting

Submit a complete update of the project schedule containing all approved progress, revisions, and adjustments, pursuant to paragraph SUBMISSION REQUIREMENTS not later than 4 working days after the periodic schedule update meeting, reflecting only those changes made during the previous update meeting.

3.6.2 Status of Activities

Update information, including Actual Start Dates (AS), Actual Finish Dates (AF), Remaining Durations (RD), and Percent Complete shall be subject to the approval of the Government prior to the meeting. As a minimum, address the following items on an activity by activity basis during each progress meeting.

3.6.2.1 Start and Finish Dates

Accurately show the status of the Actual Start and/or Actual Finish dates for each activity currently in-progress or completed since the last update. The Government may allow an Actual Finish date to be assigned with the percent complete less than 100% to account for the value of work remaining but not restraining successor activities. Only assign Actual Start dates when actual progress occurs on an activity.

3.6.2.2 Remaining Duration

Update the estimated Remaining Duration for all incomplete activities independent of Percent Complete. Remaining Durations may exceed the activity Original Durations or may exceed the activity's prior update RD if the Government considers the current Original Durations or Remaining Duration to be understated based on current progress, insufficient work crews actually manning the job, unrealistic Original Durations, or deficiencies that must be corrected that restrain successor activities.

3.6.2.3 Percent Complete

Update the percent complete for each activity started based on the realistic assessment of earned value. Activities which are complete but for remaining minor punch list work and which do not restrain the initiation of successor activities may be declared 100 percent complete. To allow for proper schedule management, cost load the correction of punch list from Government pre-final inspection at not less than 1 percent of the total contract value, which may be declared 100 percent complete upon completion and correction of all punch list work identified during Government pre-final inspection(s).

3.6.2.4 Logic Changes

Specifically identify and discuss all logic changes pertaining to NTP on change orders, change orders to be incorporated into the schedule, Contractor proposed changes in work sequence, corrections to schedule logic for out-of-sequence progress, and other changes that have been made pursuant to contract provisions. The Government will only approve logic revisions for the purpose of keeping the schedule valid in terms of its usefulness in calculating a realistic completion date, correcting erroneous logic ties, and accurately sequencing the work.

3.6.2.5 Other Changes

Other changes required due to delays in completion of any activity or group of activities include:

1) delays beyond the Contractor's control, such as strikes and unusual weather.

2) delays encountered due to submittals, Government Activities, deliveries or work stoppages which make re-planning the work necessary.

3) changes required to correct a schedule that does not represent the actual or planned prosecution and progress of the work.

3.7 REQUESTS FOR TIME EXTENSIONS

In the event the Contractor believes it is entitled to an extension of the contract performance period, completion date, or any interim milestone date, furnish the following for a determination by the Contracting Officer: justification, project schedule data, and supporting evidence as the Contracting Officer may deem necessary. Submission of proof of excusable delay, based on revised activity logic, duration, and costs (updated to the specific date that the delay occurred) is a condition precedent to any approvals by the Government. In response to each Request For Proposal issued by the Government, submit a schedule impact analysis demonstrating whether or not the change contemplated by the Government impacts the critical path.

3.7.1 Justification of Delay

The project schedule shall clearly display that the Contractor has used, in full, all the float time available for the work involved with this request. The Contracting Officer's determination as to the number of allowable days of contract extension shall be based upon the project schedule updates in effect for the time period in question, and other factual information. Actual delays that are found to be caused by the Contractor's own actions, which result in a calculated schedule delay, will not be a cause for an extension to the performance period, completion date, or any interim milestone date.

3.7.2 Submission Requirements

Submit a justification for each request for a change in the contract completion date of less than 2 weeks based upon the most recent schedule update at the time of the NTP or constructive direction issued for the change. Such a request shall be in accordance with the requirements of other appropriate Contract Clauses and shall include, as a minimum:

a. A list of affected activities, with their associated project schedule activity number.

b. A brief explanation of the causes of the change.

c. An analysis of the overall impact of the changes proposed.

d. A sub-network of the affected area.

3.7.3 Additional Submission Requirements

The Contracting Officer may request an interim update with revised activities for any requested time extension of over 2 weeks. Provide this disk within 4 days of the Contracting Officer's request.

3.8 DIRECTED CHANGES

If the NTP is issued for changes prior to settlement of price and/or time, submit proposed schedule revisions to the Contracting Officer within 2 weeks of the NTP being issued. The Contracting Officer will approve proposed revisions to the schedule prior to inclusion of those changes within the project schedule. If the Contractor fails to submit the proposed revisions, the Contracting Officer may furnish the Contractor with suggested revisions to the project schedule. Include these revisions in the project schedule until revisions are submitted, and final changes and impacts have been negotiated. If the Contractor has any objections to the revisions furnished by the Contracting Officer, advise the Contracting Officer within 2 weeks of receipt of the revisions. Regardless of the objections, continue to update the schedule with the Contracting Officer's revisions until a mutual agreement in the revisions is reached. If the Contractor fails to submit alternative revisions within 2 weeks of receipt of the Contracting Officer's proposed revisions, the Contractor will be deemed to have concurred with the Contracting Officer's proposed revisions. The proposed revisions will then be the basis for an equitable adjustment for performance of the work.

3.9 OWNERSHIP OF FLOAT

Float available in the schedule, at any time, shall not be considered for the exclusive use of either the Government or the Contractor.

-- End of Section --

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

The Contracting Officer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections.

Units of weights and measures used on all submittals are to be the same as those used in the contract drawings.

Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.

Contractor's Quality Control (CQC) System Manager to check and approve all items prior to submittal and electronically sign and date indicating action taken. Proposed deviations from the contract requirements are to be clearly identified. Include within submittals items such as: Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals.

Submittals requiring Government approval are to be scheduled and made prior to the acquisition of the material or equipment covered thereby. Pick up and dispose of samples remaining upon completion of the work in accordance with manufacturer's Material Safety Data Sheets (MSDS) and in compliance with existing laws and regulations.

1.1 DEFINITIONS

1.1.1 Submittal Descriptions (SD)

Submittals requirements are specified in the technical sections. Submittals are identified by Submittal Description (SD) numbers and titles as follows:

SD-01 Preconstruction Submittals

Submittals which are required within 15 days of contract award or notice to proceed, whichever occurs first.

Certificates of insurance
Surety bonds
List of proposed subcontractors
List of proposed products
Construction Progress Schedule
Network Analysis Schedule (NAS)
Submittal register
Schedule of prices
Health and safety plan
Work plan
Quality control(QC) plan
Environmental protection plan

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.

Field samples and mock-ups constructed on the project site establish standards by which the ensuring work can be judged. Includes assemblies or portions of assemblies which are to be incorporated into the project and those which will be removed at conclusion of the work.

SD-05 Design Data

Design calculations, mix designs, analyses or other data pertaining to a part of work.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. (Testing must have been within three years of date of contract award for the project.)

Report which includes findings of a test required to be performed by the Contractor on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report which includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports.

Daily logs and checklists.

Final acceptance test and operational test procedure.

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that product, system or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Contractor, or of a manufacturer, supplier, installer or subcontractor through Contractor, the purpose of which is to further quality of orderly progression of a portion of the work by documenting procedures, acceptability of methods or personnel qualifications.

Confined space entry permits.

Text of posted operating instructions.

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, including special notices and Material Safety Data sheets concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification actions taken by manufacturer's representative at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and must state the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data that is furnished by the manufacturer, or the system provider, to the equipment operating and maintenance personnel, including manufacturer's help and product line documentation necessary to maintain and install equipment. This data is needed by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

This data is intended to be incorporated in an operations and maintenance manual or control system.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1.1.2 Approving Authority

Office or designated person authorized to approve submittal.

1.1.3 Work

As used in this section, on- and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction.

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with this section.

SD-01 Preconstruction Submittals

Submittal register; G

1.3 SUBMITTAL CLASSIFICATION

Submittals are classified as follows:

1.3.1 Government Approved

Government approval is required for extensions of design, critical materials, deviations, equipment whose compatibility with the entire system must be checked, and other items as designated by the Contracting Officer. Within the terms of the Contract Clause entitled "Specifications and Drawings for Construction," they are considered to be "shop drawings."

1.3.2 Information Only

Submittals not requiring Government approval will be for information only. They are not considered to be "shop drawings" within the terms of the Contract Clause referred to above.

1.4 PREPARATION

1.4.1 Transmittal Form

Use the transmittal form (ENG Form 4025) for submitting both Government approved and information only submittals in accordance with the instructions on the reverse side of the form. This form will be furnished to the Contractor. Contractor shall submit this form and associated submittals digitally. Hard copies of this form will not be accepted by the Government. Hard copies of submittals will only be accepted if they are explicitly requested elsewhere in these specifications or in the contract, task order, or delivery order. Properly complete this form by filling out all the heading blank spaces and identifying each item submitted. Exercise special care to ensure proper listing of the specification paragraph and sheet number of the contract drawings pertinent to the data submitted for each item.

1.5 QUANTITY OF SUBMITTALS AND FORMAT

1.5.1 Number of Copies of SD-02 Shop Drawings

Submit digital copy (see paragraph entitled, "Drawings" for requirements for electronic drawing files) and one hard copy of submittals of shop drawings requiring review and approval only by QC organization including shop drawings requiring review and approval by Contracting Officer.

1.5.2 Number of Copies of SD-03 Product Data and SD-08 Manufacturer's Instructions

Submit in compliance with quantity requirements specified for shop drawings.

1.5.3 Number of Samples SD-04 Samples

a. Submit two samples, or sets of samples showing range of variation, of each required item. One approved sample or set of samples will be retained by approving authority and one will be returned to Contractor.

b. Submit one sample panel or provide one sample installation where directed. Include components listed in technical section or as directed.

c. Submit one sample installation, where directed.

d. Submit one sample of non-solid materials.

1.5.4 Number of Copies SD-05 Design Data and SD-07 Certificates

Submit in compliance with quantity requirements specified for shop drawings.

1.5.5 Number of Copies SD-06 Test Reports and SD-09 Manufacturer's Field Reports

Submit in compliance with quantity and quality requirements specified for shop drawings other than field test results, which will be submitted with QC reports.

1.5.6 Number of Copies of SD-10 Operation and Maintenance Data

Submit one hard copy and one digital copy (.pdf - text searchable, if scanning documents, use Optical Character Recognition (OCR)) of O&M Data to the Contracting Officer for review and approval.

1.5.7 Number of Copies of SD-01 Preconstruction Submittals and SD-11 Closeout Submittals

Unless otherwise specified, submit one digital copy of Preconstruction submittals and one hard copy and one digital copy of Closeout submittals.

1.5.8 Submittal format

1.5.8.1 Drawings

The submission of drawings will be in an electronic drawing file in AutoCAD or Microstation format and a second electronic copy in PDF format (.pdf - text searchable, if scanning documents, use Optical Character Recognition (OCR)). See A/E/C CADD Standard Release 6.0 for detailed standards for the drawings. The reference is located at https://cadbim.usace.army.mil/. Hard copies of drawings shall be ANSI size D or ISO size A1, unless otherwise indicated.

1.5.8.2 Other submittals

For catalog cuts, illustrations, printed specifications, or other data submitted, inapplicable portions shall be marked out and applicable items such as model numbers, sizes, and accessories shall be indicated by arrow or highlighted. The submittals will be provided in electronic (.pdf - text searchable, if scanning documents, use Optical Character Recognition (OCR)) format.

1.6 INFORMATION ONLY SUBMITTALS

Normally submittals for information only will not be returned. Approval of the Contracting Officer is not required on information only submittals. The Government reserves the right to require the Contractor to resubmit any item found not to comply with the contract. This does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contracting Officer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Contractor of the requirement to furnish samples for testing by the Government laboratory or for check testing by the Government in those instances where the technical specifications so prescribe.

1.7 VARIATIONS / SUBSTITUTION REQUESTS

Variations from contract requirements require Government approval pursuant to contract Clause FAR 52.236-21 and will be considered where advantageous to Government.

1.7.1 Considering Variations

Discussion with Contracting Officer prior to submission, will help ensure functional and quality requirements are met and minimize rejections and re-submittals. When contemplating a variation which results in lower cost, consider submission of the variation as a Value Engineering Change Proposal (VECP).

Specifically point out variations from contract requirements in transmittal letters. Failure to point out deviations may result in the Government requiring rejection and removal of such work at no additional cost to the Government.

1.7.2 Proposing Variations

When proposing variation, deliver written request to the Contracting Officer, with documentation of the nature and features of the variation and why the variation is desirable and beneficial to Government. If lower cost is a benefit, also include an estimate of the cost savings. In addition to documentation required for variation, include the submittals required for the item. Clearly mark the proposed variation in all documentation.

Check the column "variation" of ENG Form 4025 for submittals which include proposed deviations requested by the Contractor. Set forth in writing the reason for any deviations and annotate such deviations on the submittal. The Government reserves the right to rescind inadvertent approval of submittals containing unnoted deviations.

1.7.3 Warranting That Variations Are Compatible

When delivering a variation for approval, Contractor warrants that this contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of work.

1.7.4 Review Schedule Is Modified

In addition to normal submittal review period, a period of 10 working days will be allowed for consideration by the Government of submittals with variations.

1.8 SUBMITTAL REGISTER

Prepare an initial submittal register for review by the Government and maintain submittal register as the work progresses. Do not change data which is output in columns (c), (d) and (e) as approved by Government; retain data which is output in columns (g), (h), and (i) as approved. A submittal register showing items of equipment and materials for which submittals are required by the specifications may or may not be provided as an attachment. This list may not be all inclusive and additional submittals may be required.

Column (b) Transmittal Number: Contractor assigned list of consecutive numbers assigned in accordance with instructions provided by Government and on reverse of ENG FORM 4025.

Column (c): Lists specification section in which submittal is required.

Column (d): Lists each submittal description (SD No. and type, e.g. SD-02 Shop Drawings) required in each specification section.

Column (e): Lists one principal paragraph in specification section where a material or product is specified. This listing is only to facilitate locating submitted requirements. Do not consider entries in column (e) as limiting project requirements.

Thereafter, the Contractor is to track all submittals by maintaining a complete list, including completion of all data columns, including dates on which submittals are received and returned by the Government.

1.8.1 Use of Submittal Register

Submit submittal register with QC plan and project schedule. Verify that all submittals required for project are listed and add missing submittals. Coordinate and complete the following fields on the register submitted with the QC plan and the project schedule:

Column (a) Activity Number: Activity number from the project schedule.

Column (g) Contractor Submit Date: Scheduled date for approving authority to receive submittals.

Column (h) Contractor Approval Date: Date Contractor needs approval of submittal.

Column (i) Contractor Material: Date that Contractor needs material delivered to Contractor control.

1.8.2 Contractor Use of Submittal Register

Update the following fields in the Government-furnished submittal register program or equivalent fields in program utilized by Contractor with each submittal throughout contract.

Column (b) Transmittal Number: Contractor assigned list of consecutive numbers assigned in accordance with instructions provided by Government and on reverse of ENG FORM 4025.

Column (j) Action Code

Column (k) Date of action used to record Contractor's review when forwarding submittals to QC.

Column (l) List date of submittal transmission.

Column (q) List date approval received.

1.8.3 Approving Authority Use of Submittal Register

As determined by local policy.

1.8.4 Action Codes

Entries for columns (j) and (o), are to be used are as follows (others may be prescribed by Transmittal Form):

1.8.4.1 Government Review Action Codes

"A" - "Approved as submitted"; "Completed"

"B" - "Approved, except as noted on drawings"; "Completed"

"C" - "Approved, resubmission required"; "Resubmit"

"D" - "Returned by correspondence"; "Completed"

"E" - "Disapproved (See attached)"; "Resubmit"

"F" - "Receipt acknowledged"; "Completed"

"G" - "Other (Specify)"; "Resubmit"

"X" - "Receipt acknowledged, does not comply"; "Resubmit"

1.8.5 Copies Delivered to the Government

Contractor shall send an updated Submittal Register including date and Government code of previously processed submittals with each invoice request and with each new group of submittals or resubmittals.

1.9 SCHEDULING

Schedule and submit concurrently submittals covering component items forming a system or items that are interrelated. Include certifications to be submitted with the pertinent drawings at the same time. No delay damages or time extensions will be allowed for time lost in late submittals. An additional 14 calendar days will be allowed and shown on the register for review and approval of submittals for food service equipment and refrigeration and HVAC control systems.

a. Coordinate scheduling, sequencing, preparing and processing of submittals with performance of work so that work will not be delayed by submittal processing. Allow for potential resubmittal of requirements.

b. Submittals called for by the contract documents will be listed on the register. If a submittal is called for but does not pertain to the contract work, the Contractor is to include the submittal in the register and annotate it "N/A" with a brief explanation. Approval by the Contracting Officer does not relieve the Contractor of supplying submittals required by the contract documents but which have been omitted from the register or marked "N/A".

c. Re-submit register and annotate monthly by the Contractor with actual submission and approval dates. When all items on the register have been fully approved, no further re-submittal is required.

d. Carefully control procurement operations to ensure that each individual submittal is made on or before the Contractor scheduled submittal date shown on the approved "Submittal Register."

1.10 GOVERNMENT REVIEW OF SUBMITTALS

1.10.1 Submittal Review Period

Normal review period for submittals will be ten calendar days.

1.10.2 Government Actions

Upon completion of review of submittals, the Government will:

a. Note date on which submittal was received.

b. Review submittals for approval within scheduling period specified and only for conformance with project design concepts and compliance with contract documents.

c. Identify returned submittals with one of the actions defined in paragraph entitled "Government Review Action Codes" and with markings appropriate for action indicated.

Upon completion of review of submittals requiring Government approval, Government will enter appropriate action code on submittal and transmittal form, add comments if applicable, digitally sign submittal and transmittal form, and return digital copies of submittal and transmittal form to Contractor. If the Government performs a conformance review of other Designer of Record approved submittals, the submittals will be so identified and returned, as described above.

1.10.3 Rejected or Disapproved Submittals

Resubmission or revisions of disapproved or rejected submittals shall be accomplished within seven (7) calendar days after receipt of notification that a submittal has been disapproved. The Contractor shall be responsible for any delay or adverse impact that disapproved or rejected submittals may have on the performance of the contract.

1.11 DISAPPROVED OR REJECTED SUBMITTALS

Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications; notice as required under the clause entitled, "Changes" is to be given to the Contracting Officer. Contractor is responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

If changes are necessary to submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change is to be accomplished until the changed submittals are approved.

1.12 APPROVED SUBMITTALS

The Government's approval or acceptance of submittals is not be construed as a complete check, and indicates only that the general method of construction, materials, detailing and other information are satisfactory. Approval or acceptance will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor under the Contractor Quality Control (CQC) requirements of this contract is responsible for design, dimensions, all design extensions, such as the design of adequate connections and details, etc., and the satisfactory construction of all work. After submittals have been approved or accepted by the Contracting Officer, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

1.13 APPROVED SAMPLES

Approval of a sample is only for the characteristics or use named in such approval and is not be construed to change or modify any contract requirements. Before submitting samples, the Contractor to assure that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been approved.

Match the approved samples for Materials and equipment incorporated in the work. If requested, approved samples, including those which may be damaged in testing, will be returned to the Contractor, at his expense, upon completion of the contract. Samples not approved will also be returned to the Contractor at its expense, if so requested.

Failure of any materials to pass the specified tests will be sufficient cause for refusal to consider, under this contract, any further samples of the same brand or make of that material. Government reserves the right to disapprove any material or equipment which previously has proved unsatisfactory in service.

Samples of various materials or equipment delivered on the site or in place may be taken by the Contracting Officer for testing. Samples failing to meet contract requirements will automatically void previous approvals. Contractor to replace such materials or equipment to meet contract requirements.

Approval of the Contractor's samples by the Contracting Officer does not relieve the Contractor of his responsibilities under the contract.

1.14 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained.

1.15 CONTRACTOR CERTIFICATION

Contractor's digital signature on transmittal form(s) will be construed by Government that submittals referenced by the transmittal form(s) meets contract requirements.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
2014-OMA-SPECIFICATIONS_REVISION1_2015

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION / GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	CONTRACTOR: SCHEDULE DATES APPROVAL NEEDED BY	CONTRACTOR: SCHEDULE DATES MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	CONTRACTOR ACTION DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	APPROVING AUTHORITY DATE RCD FROM OTH REVIEWER	APPROVING AUTHORITY ACTION CODE	APPROVING AUTHORITY DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		01 30 00	SD-01 Preconstruction Submittals														
			View location map	1.4	G												
			Progress and completion pictures	1.5													
		01 32 01.00 10	SD-01 Preconstruction Submittals														
			Preliminary Project Schedule	3.4.1	G												
			Initial Project Schedule	3.4.2	G												
			Initial Project Schedule	3.4.2	G												
			Periodic Schedule Updates	3.4.3	G												
			Schedule Status Report	3.1.2	G												
		01 33 00	SD-01 Preconstruction Submittals														
			Submittal register	1.8	G												
		01 33 29	SD-01 Preconstruction Submittals														
			LEED Implementation Plan	1.4	G												
			SD-07 Certificates														
			LEED LEED NC Accredited	1.4	G												
			Professional (Building Design &														
			Construction Specialty)														
			SD-11 Closeout Submittals														
			LEED Documentation Notebook	1.5	G												
		01 35 26	SD-01 Preconstruction Submittals														
			SAFETY PLAN /ACCIDENT	1.6													
			PREVENTION PLAN (APP)														
			Activity Hazard Analysis (AHA)	1.7													
			Crane Critical Lift Plan	1.6.1													
			Crane Operators	1.5.1.2													
			SD-06 Test Reports														

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
2014-OMA-SPECIFICATIONS_REVISION1_2015

CONTRACTOR

						CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		01 35 26	Notifications and Reports	1.11													
			Accident Reports	1.11.2													
			Crane Reports	1.11.3													
			Certificate of Compliance	1.11.4													
			SD-07 Certificates														
			Confined Space Entry Permit	1.8													
			Hot work permit	1.8													
			License Certificates	1.13													
		01 35 29.13	SD-02 Shop Drawings														
			Work Zones	1.20.1	G												
			Decontamination Facilities	1.21.1	G												
			SD-03 Product Data														
			Exposure Monitoring/Air	1.13													
			Sampling Program														
			Site Control Log	1.20.2													
			Employee Certificates	1.12.4													
		01 45 00.00 10	SD-01 Preconstruction Submittals														
			Quality Control Plan	3.2	G												
		01 50 00	SD-01 Preconstruction Submittals														
			Construction site plan	1.4	G												
			Traffic control plan	3.4.1	G												
			Temporary Power Services	3.3.4													
			Diagram														
			SD-06 Test Reports														
			Backflow Preventer Tests	1.5	G												
			SD-07 Certificates														

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		01 50 00	Backflow Prevention Training	1.5.2	G													
			Certificate															
			Backflow Preventers	1.5.1														
		01 57 20.00 10	SD-01 Preconstruction Submittals															
			Environmental Protection Plan	1.7	G													
		01 58 00	SD-02 Shop Drawings															
			Construction Project Sign	1.2.1	G													
		01 74 19	SD-01 Preconstruction Submittals															
			Waste Management Plan	1.6	G													
			SD-11 Closeout Submittals															
			Records	1.7														
		01 78 00	SD-03 Product Data															
			As-Built Record of Equipment	1.3.2														
			and Materials															
			Equipment-in-Place List	1.3.4														
			Warranty Management Plan	1.6.1														
			Warranty Tags	1.6.5														
			Spare Parts Data	1.4														
			SD-08 Manufacturer's Instructions															
			Preventative Maintenance	1.5														
			Condition Monitoring (Predictive	1.5														
			Testing)															
			Inspection	1.5														
			Instructions	1.6.1														
			SD-10 Operation and Maintenance															
			Data															

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		01 78 00	Operation and Maintenance	1.7													
			Manuals														
			SD-11 Closeout Submittals														
			Record Drawings	1.3.1													
			Interim Form DD1354	1.9	G												
			Checklist for Form DD1354	1.9	G												
		02 41 00	SD-01 Preconstruction Submittals														
			Existing Conditions	1.11	G												
			SD-07 Certificates														
			Demolition Plan	1.2.1	G												
			Deconstruction Plan	1.2.1	G												
			Notification	1.7	G												
			SD-11 Closeout Submittals														
			Receipts	3.3.4													
		02 61 13	SD-02 Shop Drawings														
			Surveys	3.1	G												
			SD-03 Product Data														
			Work Plan	1.2	G												
			Closure Report	3.11	G												
			SD-06 Test Reports														
			Backfill	2.2	G												
			Surveys	3.1	G												
			Confirmation Sampling and	3.5	G												
			Analysis														
			Sampling of Stored Material	3.7.1	G												
			Sampling Liquid	3.7.2	G												

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		02 61 13	Compaction	3.9.2	G													
		02 65 00	SD-01 Preconstruction Submittals															
			Work Plan	1.4.4	G													
			Site safety and health plan	1.4.4.1	G													
			Excavation and material handling plan	1.4.4.2	G													
			Field sampling and laboratory testing plan	1.4.4.3	G													
			Tank and piping removal and disposal plan	1.4.4.4	G													
			Spill and discharge control plan	1.4.4.5	G													
			Qualifications	1.4.1	G													
			Laboratory Services	1.4.2	G													
			SD-06 Test Reports															
			Backfill Material	2.1	G													
			Tank Contents Verification	3.2	G													
			Contaminated Water Disposal	3.5.2	G													
			Soil Examination, Testing, and Analysis	3.10	G													
			Backfilling	3.11	G													
			Tank Closure Report	3.15	G													
			SD-11 Closeout Submittals															
			Salvage Rights	3.12.4	G													
			Tank Closure Report	3.15	G													
		02 81 00	SD-03 Product Data															

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		02 81 00	Onsite Hazardous Waste Management	3.1	G													
			Notices of Non-Compliance and Notices of Violation	3.2														
			Packaging Notifications	2.1.1														
			SD-06 Test Reports															
			Record keeping	3.6	G													
			Spill Response	3.7														
			Exception Report	3.6	G													
			SD-07 Certificates															
			Certification	1.4.3														
			Security Plan	3.2.4														
			Transportation and Disposal Coordinator	1.4.1	G													
			Training	1.4.2	G													
			EPA Offsite Policy	3.2.2														
			Certificates of Disposal	3.2.5														
			Shipping Documents and Packagings Certification	3.2.3	G													
			Waste Minimization	3.5	G													
		02 82 14.00 10	SD-02 Shop Drawings															
			Detailed Drawings	1.3	G													
			SD-03 Product Data															
			Asbestos Waste Shipment Records	3.11.3.1														
			Encapsulants	2.1														

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		02 82 14.00 10	Respiratory Protection Program	1.8.1	G													
			Cleanup and Disposal	3.11														
			Qualifications	1.5.1	G													
			Training Program	1.10														
			Licenses, Permits and Notifications	1.7.1														
			Asbestos Management Plan	3.11.3.2														
			SD-06 Test Reports															
			Exposure Assessment and Air Monitoring	3.9														
			Local Exhaust System	1.6.3														
			SD-07 Certificates															
			Local Exhaust System	1.6.3														
			Encapsulants	2.1	G													
			Medical Surveillance Requirements	1.8														
		02 83 19.00 10	SD-03 Product Data															
			Materials and Equipment	2.1														
			Expendable Supplies	2.1.1														
			Qualifications	1.5.1	G													
			Occupant Protection Plan	1.5.4	G													
			SD-06 Test Reports															
			Pressure Differential Log	3.1.3														
			Licenses, Permits and Notifications	1.5.5	G													
			Sampling and Analysis	1.3.3														

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		02 83 19.00 10	Abatement Report	3.5	G													
		03 11 13.00 10	SD-02 Shop Drawings															
			Formwork	3.1.1														
			SD-03 Product Data															
			Design	1.2														
			Form Materials	2.1														
		03 15 00.00 10	SD-03 Product Data															
			Preformed Expansion Joint Filler	2.2														
			Sealant	2.3														
			Waterstops	2.4														
		03 20 00.00 10	SD-02 Shop Drawings															
			Reinforcement	3.1														
			SD-03 Product Data															
			Epoxy-Coated Bars	2.3.2														
			SD-07 Certificates															
			Welding Qualifications	1.3.1														
			Reinforcing Steel	2.3														
		03 30 00	SD-02 Shop Drawings															
			Fabrication Drawings	1.6.2.1														
			Reinforcing steel	1.6.2.3	G													
			Synthetic reinforcing fibers	2.5.5														
			SD-03 Product Data															
			Portland Cement	2.4.1.3														
			Ready-Mix Concrete	2.3.2														
			Bonding Materials	2.6														
			Pumping Concrete	1.6.3.2														

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		03 30 00	Epoxy bonding compound	2.4.11														
			Waterstops	3.14.2														
			SD-05 Design Data															
			Concrete mix design	1.6.4.1	G													
			Calculations	1.6.1.1														
			SD-06 Test Reports															
			Concrete mix design	1.6.4.1	G													
			Ground granulated blast-furnace slag	1.6.4.3														
			Tolerance report	3.10.2.1														
			Compressive strength tests	3.12.2.3														
			Unit weight of structural lightweight concrete	3.12.2.5														
			Air Content	2.8.5														
			Air Content	3.12.2.4														
			Slump Tests	3.12.2.1														
			Temperature Tests	3.12.2.2														
			Ion Concentration	3.12.2.6														
			SD-07 Certificates															
			Curing concrete elements	1.6.3.1														
			VOC Content for form release agents, curing compounds, and concrete penetrating sealers	1.6.3.4														
			Material Safety Data Sheets	1.6.3.5														
			Welder Qualifications	1.9														
			Welding Procedures	1.9														

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		03 30 00	Classification and Quality of	2.8													
			Concrete														
			Steel Bar	3.6.11													
			SD-08 Manufacturer’s Instructions														
			Fly ash	1.6.4.2													
		03 30 53	SD-02 Shop Drawings														
			Installation Drawings	1.5													
			SD-03 Product Data														
			Ready-Mix Concrete	2.2													
		03 40 00.00 10	SD-01 Preconstruction Submittals														
			Quality Control Procedures	1.4.1.2													
			SD-02 Shop Drawings														
			Standard Precast Units	1.2.1													
			Custom-Made Precast Units	1.2.2													
			SD-03 Product Data														
			Standard Precast Units	1.2.1													
			Proprietary Precast Units	1.2.3													
			Embedded Items	3.1.3													
			Accessories	2.1.11													
			SD-05 Design Data														
			Design Calculations	1.2.2													
			Concrete Mix Proportions	1.2.5.1													
			SD-06 Test Reports														
			Test Reports	1.4.1.4													
		03 41 16.08	SD-02 Shop Drawings														
			Fabrication Drawings	2.1	G												

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		03 41 16.08	Installation Drawings	2.1	G													
			SD-03 Product Data															
			Precast Curb Units	2.3.2														
			Absorption Cover	2.3.7														
			Moisture-Retaining Cover	2.3.7														
			Cement Grout Joint Sealing	2.3.3														
			Materials															
			SD-05 Design Data															
			Design analysis	2.3.1														
			Calculations	2.3.1														
			SD-06 Test Reports															
			Nail Driving and Nail Pulling	2.3.1														
			Tests															
			Strength Tests	2.3.1	G													
			SD-07 Certificates															
			Precast Concrete Roof Slabs	2.3.1	G													
			Precast Curb Units	2.3.2	G													
			Cement Grout Joint Sealing	2.3.3														
			Materials															
			SD-08 Manufacturer’s Instructions															
			Installation Instructions	2.3.1														
		04 20 00	SD-02 Shop Drawings															
			Detail Drawings	1.4.4														
			SD-03 Product Data															
			Concrete Masonry Units (CMU)	2.4														
			Concrete Brick	2.3	G													

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		04 20 00	Clay or Shale Brick	2.2	G													
			Cement	2.8.4	G													
			Cold Weather Installation	1.6.2	G													
			Precast Concrete Items	2.5	G													
			Fire-rated CMU	2.4.3	G													
			SD-05 Design Data															
			Pre-mixed Mortar	2.8.5														
			Unit Strength Method	1.2.1.1														
			SD-06 Test Reports															
			Efflorescence Test	3.24.3														
			Field Testing of Mortar	3.24.1														
			Field Testing of Grout	3.24.2														
			Prism tests	3.24.4	G													
			SD-07 Certificates															
			Masonry Inspector Qualifications	1.4.3	G													
		05 05 23	SD-03 Product Data															
			Welding Procedures	1.5	G													
			SD-06 Test Reports															
			Nondestructive Examination	3.3.1														
			SD-07 Certificates															
			Welder, Welding Operator, and	1.5.5														
			Tacker Qualification															
			Inspector Qualification	1.5.6														
			Previous Qualifications	1.5.2														
		05 12 00	SD-02 Shop Drawings															
			Fabrication drawings	1.5.1	G													

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		05 12 00	SD-03 Product Data															
			Steel	2.1														
			Bolts, nuts, and washers	2.2														
			Bolts, nuts, and washers	2.2														
			SD-07 Certificates															
			Welding procedures and qualifications	1.5.2.3														
		05 21 23	SD-01 Preconstruction Submittals															
			Material Safety Data Sheet	1.5.2														
			SD-02 Shop Drawings															
			Steel joist girder framing	1.5.1	G													
			SD-07 Certificates															
			Welder qualification	1.5.2														
			Certification of Compliance	1.5.2														
		05 30 00	SD-02 Shop Drawings															
			Fabrication Drawings	1.3.5														
			SD-03 Product Data															
			Deck Units	2.3.1														
			Galvanizing Repair Paint	2.1.3.1														
			Mechanical Fasteners	2.2.12														
			Metal Floor Deck Units	2.3.2														
			Welding Equipment	1.3.3														
			Welding Rods and Accessories	1.3.3														
			SD-05 Design Data															
			Deck Units	2.3.1														
			SD-07 Certificates															

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		05 30 00	Welder Qualifications	1.3.3													
			Powder-Actuated Tool Operator	1.3.2													
		05 50 13	SD-02 Shop Drawings														
			Fabrication drawings	1.4.2	G												
			SD-03 Product Data														
			Cover plates and frames	2.6													
			Floor gratings and roof walkways	2.9													
			Wheel guards	2.17													
			Window and door guards	2.18													
			Roof hatch	3.11													
		05 50 14	SD-02 Shop Drawings														
			Detail Drawings	1.3.2	G												
			SD-03 Product Data														
			Welding of Structural Steel	2.2.2.1													
			Structural Steel Welding Repairs	2.3.4	G												
			Materials List	2.1.1													
			SD-06 Test Reports														
			Tests, Inspections, and	2.3													
			Verifications														
			SD-07 Certificates														
			Qualification of Welders and	1.3.1													
			Welding Operators														
			Application Qualification for Steel	2.2.2.3													
			Studs														
			Welding of Aluminum	1.3.1	G												
		05 51 00	SD-02 Shop Drawings														

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		05 51 00	Metal Stair System	2.16	G													
			SD-03 Product Data															
			Structural Steel Tubing	2.3	G													
			Hot-Rolled Carbon Steel Bars	2.4														
			Cold-Rolled Carbon Steel Sheets	2.7														
			Galvanized Carbon Steel Sheets	2.8														
			Cold-Drawn Steel Tubing	2.9														
			Concrete Inserts	2.13	G													
			Masonry Anchorage Devices	2.14	G													
			Steel Stairs	2.18.8	G													
			Steel Stairs, Circular	2.18.9	G													
		05 51 33	SD-02 Shop Drawings															
			Ladder fabrication and installation	1.4														
			drawings															
			SD-03 Product Data															
			Ladders	2.3														
		05 52 00	SD-02 Shop Drawings															
			Fabrication and Installation	2.1														
			Drawings															
			SD-03 Product Data															
			Steel Railings and Handrails	2.13														
			Aluminum Railings and Handrails	2.14														
			SD-07 Certificates															
			Welding Procedures	1.3.1	G													
			Welder Qualification	1.3.2	G													
			SD-08 Manufacturer’s Instructions															

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		05 52 00	Installation Instructions	3.1	G													
		06 10 00	SD-02 Shop Drawings															
			Fabricated structural members	1.9.1	G													
			Modifications of structural members	1.9.1	G													
			Modifications of structural members	1.9.2	G													
			SD-03 Product Data															
			Underlayment	2.4														
			Plastic Lumber	2.1.2														
			Fiberboard Wall Sheathing	2.5.2														
			Cellulose Honeycomb Panels	2.5.5														
			Fire-retardant treatment	1.8														
			Engineered wood products	2.1.1														
			Structural-use and OSB panels	1.4.4														
			Oriented Strand Board	2.3														
			Adhesives	2.5.11														
			SD-05 Design Data															
			Modifications of structural members	1.9.1	G													
			Modifications of structural members	1.9.2	G													
			SD-06 Test Reports															
			Preservative-treated	1.4.5														
			SD-07 Certificates															
			Certificates of grade	1.9.3														

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		06 10 00	Preservative treatment	1.7														
		06 20 00	SD-02 Shop Drawings															
			Detail Drawings	1.3														
			SD-03 Product Data															
			Siding	2.1.12	G													
			Siding	2.1.12	G													
			Epoxy-Aggregate Panels	2.1.12.9														
			SD-07 Certificates															
			Certificates of grade	1.4														
			Certificates of compliance	1.4														
		07 11 13	SD-07 Certificates															
			Materials	1.3														
		07 12 00	SD-03 Product Data															
			Protection board	2.6														
			Prefabricated copper fabric	2.8														
			Membrane fabric	2.3														
			SD-06 Test Reports															
			Liquid asphalt	1.4.2														
		07 13 53	SD-03 Product Data															
			Elastomeric waterproofing sheet material	2.1	G													
			Protection board	2.5														
			Primers, adhesives, and mastics	2.1														
			SD-06 Test Reports															
			Field Quality Control	3.6														
			Verification Of Conditions	3.1														

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		07 13 53	SD-08 Manufacturer’s Instructions															
			Primers, Adhesives and Mastics	2.1														
			(MSDS)															
		07 14 00	SD-03 Product Data															
			Fluid-applied membrane	2.1														
			Elastomeric sheet	2.8														
			Flexible foam-backed elastomeric	2.10														
			sheet															
			Bond breaker	2.7														
			SD-11 Closeout Submittals															
			Warranty	1.6														
			Information Card	3.6														
			Instructions To Government	3.5														
			Personnel															
		07 21 13	SD-03 Product Data															
			Block or board insulation	2.1														
			Vapor retarder	2.2														
			Pressure sensitive tape	2.3														
		07 21 16	SD-03 Product Data															
			Blanket insulation	2.1														
			Sill sealer insulation	2.2														
			Vapor retarder	2.4														
			Pressure sensitive tape	2.5														
		07 22 00	SD-02 Shop Drawings															
			Tapered roof insulation system	1.3	G													
			SD-03 Product Data															

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		07 22 00	Insulation	2.1														
			SD-07 Certificates															
			Manufacturer's Certificate	1.4														
		07 24 00	SD-02 Shop Drawings															
			Shop drawings	3.3	G													
			SD-03 Product Data															
			Sheathing board	2.2														
			Thermal insulation	2.6														
			Adhesive	2.3														
			Accessories	2.12														
			Base coat	2.7														
			Reinforcing fabric	2.9														
			Finish coat	2.10														
			Joint Sealant	2.13														
			Insulation Board	1.4.5														
			Warranty	1.7														
			SD-05 Design Data															
			Moisture analysis	1.2.4														
			SD-06 Test Reports															
			Abrasion resistance	1.2.3.1														
			Accelerated weathering	1.2.3.2														
			Impact resistance	1.2.2.3														
			Mildew resistance	1.2.3.3														
			Salt spray resistance	1.2.3.4														
			Absorption-freeze-thaw	1.2.3.6														
			Wall fire test	1.2.1.3														

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		07 24 00	Wind load	1.2.1.2														
			Water penetration	1.2.1.1														
			Water resistance	1.2.3.5														
			Surface Burning Characteristics	1.2.2.1														
			SD-07 Certificates															
			Qualifications of EIFS	1.4.1														
			Manufacturer															
			Qualification of EIFS Installer	1.4.2														
			Qualification of Sealant Applicator	1.4.3														
			SD-08 Manufacturer's Instructions															
			Installation of EIFS	3.3														
			SD-10 Operation and Maintenance															
			Data															
			Maintenance of EIFS	3.7														
		07 31 13	SD-03 Product Data															
			Shingles	2.1.1														
		07 32 13	SD-02 Shop Drawings															
			Clay Tile Roofing System	1.7.2														
			SD-03 Product Data															
			Clay Roof Tile	2.1.1														
			Concrete Roof Tile	2.1.2														
			Underlayment membrane	2.2														
			Glass mesh mortar units	2.3.1														
			Fiberglass-faced gypsum roof	2.3.2														
			board															
			Warranty	1.4.1														

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		07 32 13	SD-07 Certificates														
			Qualifications of roofing personnel	1.7.1													
		07 41 13	SD-02 Shop Drawings														
			Drawings	1.4.5	G												
			SD-03 Product Data														
			Roof panels	2.1													
			Accessories	2.4													
			Underlayments	2.7	G												
			Coil Stock	1.4.5	G												
			Warranty	3.11													
			SD-06 Test Reports														
			Leakage Test Report	1.2.1.1	G												
			Wind Uplift Test Report	1.2.1.2	G												
			SD-07 Certificates														
			Roofing Panels	1.4.1.1	G												
			Coil stock compatibility	1.4.5													
			Qualification of Manufacturer	1.4.1	G												
			Qualification of Applicator	1.4.2													
			SD-08 Manufacturer’s Instructions														
			INSTALLATION MANUAL	1.4.5													
			SD-11 Closeout Submittals														
			Warranties	1.8													
			Information Card	3.10													
		07 42 13	SD-02 Shop Drawings														
			Installation Drawings	1.5.1.1													

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						CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		07 42 13	SD-03 Product Data														
			Wall Panels	2.2.1													
			Sealants and Caulking	2.5.4.1													
			SD-05 Design Data														
			Wind load design analysis	1.5.1.2	G												
			SD-06 Test Reports														
			Wind Load Tests	1.3.2	G												
			SD-07 Certificates														
			Qualification of Manufacturer	1.5.3													
			Qualification of Installation	1.5.4													
			Contractor														
			Qualification of Welders	1.5.4.1													
			Coil Stock	1.5.3.1													
			Fasteners	1.5.3.1													
			Galvanizing Repair Paint	1.5.3.1													
			Enamel Repair Paint	1.5.3.1													
			SD-08 Manufacturer's Instructions														
			Installation of Wall panels	1.5.1	G												
			SD-11 Closeout Submittals														
			Warranty	1.8	G												
			Maintenance Instructions	1.5.6													
		07 51 13	SD-03 Product Data														
			Asphalt	2.4													
			Fiberglass Felt Materials	2.2	G												
			Granule Surface Modified	2.5.2	G												
			Bitumen Cap Sheet														

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		07 51 13	Base Flashing Membrane	2.3														
			Primer	2.6														
			Asphalt Roof Cement	2.7														
			Pre-Manufactured Accessories	2.11	G													
			Pre-Manufactured Accessories	2.11	G													
			Roof Walkways	2.12.1														
			Warranty	1.8														
			SD-06 Test Reports															
			Samples of Built-Up Roofing	3.5.3														
			SD-07 Certificates															
			Qualifications of Applicator	1.4.1														
			SD-11 Closeout Submittals															
			Information Card	3.6														
		07 53 23	SD-02 Shop Drawings															
			Roof Plan Drawing	1.3.1														
			Wind Load Calculations	1.3.1														
			SD-03 Product Data															
			Ballast Pavers	2.1.9.2														
			EPDM Sheet	2.1.1														
			Flashings	2.1.7														
			Flashing Accessories	2.1.7														
			Fasteners and Plates	2.1.8														
			Ballast	2.1.9														
			Roof Insulation	2.1.13														
			Protection Mat	2.1.10														
			Pre-Manufactured Accessories	2.1.11														

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		07 53 23	Warranty	1.8														
			SD-05 Design Data															
			Wind Uplift Calculations	1.4.4	G													
			SD-06 Test Reports															
			Roof Drain Test	3.8.2														
			SD-07 Certificates															
			Qualification of Manufacturer	1.4.1														
			Qualification of Applicator	1.4.2														
			Wind Uplift Resistance	1.4.4	G													
			Fire Resistance	1.4.3	G													
			SD-08 Manufacturer’s Instructions															
			Application	3.2														
			Application Method	3.2.3														
			Instructions For Membrane	3.3.2														
			Flashing															
			SD-11 Closeout Submittals															
			Information Card	3.10														
			Instructions To Government	3.9														
			Personnel															
		07 60 00	SD-02 Shop Drawings															
			Drawings	1.5														
			SD-03 Product Data															
			Flashing	3.1.2														
			Flashing	3.1.11														
			SD-11 Closeout Submittals															
			Quality Control Plan	3.5														

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		07 61 14.00 20	SD-02 Shop Drawings															
			Roofing	1.2.5	G													
			SD-03 Product Data															
			Roofing panels	2.1														
			Attachment clips	2.3														
			Closures	2.4.1														
			Accessories	2.4														
			Fasteners	2.4.2														
			Sealants	2.4.3														
			Insulation	2.5														
			warranty	1.7														
			SD-04 Samples															
			panel	2.1														
			Accessories	2.4														
			Sealants	2.4.3														
			Intermediate Support	2.2														
			SD-05 Design Data															
			Design calculations	1.5														
			SD-06 Test Reports															
			Field Inspection	3.6														
			Structural performance	1.3.3														
			Finish	1.6.6														
			SD-07 Certificates															
			Manufacturer's Technical	1.6.3														
			Representative															
			Installer's Qualifications	1.6.4														

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		07 61 14.00 20	Coil stock	2.1														
			SD-08 Manufacturer's Instructions															
			Installation	3.3														
			SD-11 Closeout Submittals															
			Information card	3.8														
		07 72 00	SD-02 Shop Drawings															
			Roof Ventilators	3.1														
		07 81 00	SD-03 Product Data															
			Fireproofing Material	3.3	G													
			SD-04 Samples															
			Spray-Applied Fireproofing	2.1														
			SD-06 Test Reports															
			Fire Resistance Rating	1.2.2														
			Field Tests	3.6	G													
			SD-07 Certificates															
			Installer Qualifications	1.4.1														
			Surface Preparation Report	3.1	G													
		07 84 00	SD-02 Shop Drawings															
			Detail Drawings	1.2.3	G													
			SD-03 Product Data															
			Firestopping Materials	2.1	G													
			SD-07 Certificates															
			Firestopping Material Certificate	1.2.3														
			Installer Qualifications	1.4.1														
		07 92 00	SD-03 Product Data															
			Sealants	2.1														

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		08 11 13	SD-02 Shop Drawings														
			Door Drawings	1.4	G												
			Door Schedule	1.4	G												
			SD-03 Product Data														
			Doors	2.1													
			Frames	2.7													
			Accessories	2.5													
		08 11 16	SD-02 Shop Drawings														
			Door and Frame Drawings	1.5.1	G												
			SD-03 Product Data														
			Doors and Frames	2.1													
			SD-10 Operation and Maintenance														
			Data														
			Maintenance of Doors and	3.3													
			Frames														
		08 14 00	SD-02 Shop Drawings														
			Door Drawings	1.4	G												
			SD-03 Product Data														
			Doors	2.1													
			Warranty	1.5													
			Fire Resistance Rating	2.1.7	G												
		08 33 13	SD-02 Shop Drawings														
			Detail Drawings	1.4													
			SD-03 Product Data														
			Rolling Counter Doors	1.2													

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		08 33 13	Rolling Counter Door	2.2														
			(Non-Rated)															
			Fire-Rated Rolling Counter Door	2.3														
			SD-10 Operation and Maintenance															
			Data															
			Rolling Counter Doors	3.5														
			(Non-Rated)															
			Fire-Rated Rolling Counter Doors	3.5														
			Cleaning	3.5														
		08 33 23	SD-02 Shop Drawings															
			Overhead Coiling Door Detail	1.5														
			Drawings															
			SD-03 Product Data															
			Overhead Coiling Doors	2.1														
			Warranty	1.6														
			Hardware	2.2														
			Counterbalancing Mechanism	2.3														
			Manual Door Operators	2.4														
			Electric Door Operators	2.5														
			Fire-Rated Door Assembly	2.6														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	1.6														
			Manuals															
		08 36 13	SD-02 Shop Drawings															
			Drawings	1.3	G													

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		08 36 13	SD-03 Product Data															
			Doors	2.2														
			Electric operators	2.6														
			SD-08 Manufacturer’s Instructions															
			Installation Instructions	3.1														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.4														
		08 51 13	SD-02 Shop Drawings															
			Installation Drawings	1.4.1	G													
			Fabrication Drawings	1.4.1														
			SD-03 Product Data															
			Windows	2.1														
			Hardware	2.2.8.1														
			Thermal-Barrier Windows	2.4														
			Mullions	2.5														
			Screens	2.2.10														
			Weatherstripping	2.2.2														
			Accessories	2.2.8														
			Thermal Performance	1.9.5														
			Warranty	1.11														
			SD-05 Design Data															
			Structural Calculations For	2.1	G													
			Deflection															
			Design Analysis	1.4.2	G													
			SD-06 Test Reports															

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		08 51 13	Minimum condensation	1.4.3														
			resistance factor															
			Resistance to forced entry	1.4.3														
			Standard Airblast Test	1.4.3														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.5														
			Manuals															
		08 52 00	SD-02 Shop Drawings															
			Installation Drawings	1.3	G													
			SD-03 Product Data															
			Engineered Wood Products	2.1.1														
			Wood windows	2.2														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.5														
			Manuals															
		08 71 00	SD-02 Shop Drawings															
			Hardware schedule	1.3														
			Keying system	2.3.8														
			SD-03 Product Data															
			Hardware items	2.3	G													
		08 81 00	SD-02 Shop Drawings															
			Installation	1.6														
			SD-03 Product Data															
			Insulating Glass	2.2														

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		08 81 00	Plastic Glazing	2.3														
			Warranty	1.7														
		08 87 16	SD-03 Product Data															
			Fragment Retention Film	2.2														
			Warranty	1.6														
			SD-06 Test Reports															
			Certified Test Reports	1.2.2														
			Impact Performance	2.2.1														
			SD-07 Certificates															
			Statement	1.2.2														
			SD-08 Manufacturer’s Instructions															
			Application and Cleaning	1.2.2														
			Instructions															
		08 91 00	SD-02 Shop Drawings															
			Wall louvers	1.4														
			SD-03 Product Data															
			Metal Wall Louvers	2.2														
		09 22 00	SD-02 Shop Drawings															
			Metal support system	1.4														
			SD-03 Product Data															
			Metal Support Systems	2.1														
		09 22 36	SD-03 Product Data															
			Lath	2.1														
		09 24 23	SD-02 Shop Drawings															
			Lath	3.3														
			SD-03 Product Data															

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		09 24 23	Proportions and Mixing	3.6														
		09 29 00	SD-03 Product Data															
			Gypsum Board	2.1.1														
			Cementitious backer units	2.1.8														
			Glass Mat Water-Resistant	2.1.4														
			Gypsum Tile Backing Board															
			Water-Resistant Gypsum Backing	2.1.3														
			Board															
			Glass Mat Covered or Reinforced	2.1.5														
			Gypsum Sheathing															
			Glass Mat Covered or Reinforced	2.1.5.1														
			Gypsum Sheathing Sealant															
			Impact Resistant Gypsum Board	2.1.6														
			Accessories	2.1.14														
			SD-07 Certificates															
			Asbestos Free Materials	2.1	G													
		09 30 00	SD-02 Shop Drawings															
			Detail Drawings	1.3	G													
			SD-03 Product Data															
			Tile	2.1	G													
			Setting-Bed	2.2														
			Mortar, Grout, and Adhesive	2.4														
			SD-06 Test Reports															
			Testing	3.7	G													
		09 51 00	SD-02 Shop Drawings															
			Approved Detail Drawings	1.2														

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		09 51 00	SD-03 Product Data															
			Acoustical Units	2.1														
			SD-06 Test Reports															
			Fire Resistive Ceilings	1.2.1														
			Ceiling Attenuation Class and	1.2.2														
			Test															
		09 64 29	SD-02 Shop Drawings															
			Squash and Handball Court Walls	3.2.2	G													
			SD-03 Product Data															
			Bamboo	2.1.2														
			Installation	3.2														
		09 64 66	SD-02 Shop Drawings															
			Hardwood strip flooring	2.1														
			SD-03 Product Data															
			Hardwood strip flooring	2.1														
			SD-04 Samples															
			Strip flooring	2.2.1														
			Hardwood base	2.2.2														
			Molded-rubber base	2.2.3														
			Steel channels and clips	2.2.4														
			Flexible foam underlayment	2.2.6														
			Cushions and pads	2.2.5														
			SD-06 Test Reports															
			Testing and Certification	1.3														
			SD-08 Manufacturer’s Instructions															
			system	2.1														

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		09 64 66	Adhesive	3.2.1														
			SD-10 Operation and Maintenance															
			Data															
			strip flooring	2.2.1														
		09 65 00	SD-02 Shop Drawings															
			Scaled Drawings	2.17														
			SD-03 Product Data															
			Resilient Flooring and	2.17														
			Accessories															
			Adhesives	2.13														
			Sheet Linoleum	2.6														
			Linoleum Tile	2.7														
			Cork	2.8														
			SD-06 Test Reports															
			Moisture, Alkalinity and Bond	3.3														
			Tests															
			SD-08 Manufacturer’s Instructions															
			Installation	3.1														
			SD-10 Operation and Maintenance															
			Data															
			Resilient Flooring and	2.17														
			Accessories															
		09 65 66	SD-02 Shop Drawings															
			Approved Detail Drawings	3.3.6.1	G													
			SD-03 Product Data															
			Installation	3.3														

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		09 68 00	SD-02 Shop Drawings															
			Installation	3.4	G													
			SD-03 Product Data															
			Carpet	2.1	G													
			Carpet Cushion	2.1	G													
			Carpet Moldings	2.1	G													
			SD-06 Test Reports															
			Moisture and Alkalinity Tests	3.2														
			SD-07 Certificates															
			Carpet Cushion and Molding	1.3														
			SD-08 Manufacturer's Instructions															
			Printed Installation Instructions	3.1														
			SD-10 Operation and Maintenance															
			Data															
			Cleaning and Protection	3.5														
		09 69 13	SD-02 Shop Drawings															
			Detailed Installation Drawings	1.4	G													
			SD-03 Product Data															
			Floor Panels	2.1														
			SD-05 Design Data															
			Compliance with ICC-ES AC300	1.2														
			Seismic Calculations	1.2.7														
			SD-06 Test Reports															
			Electrical Resistance	3.2.2														
			Acceptance Tests	3.2.1														
			SD-07 Certificates															

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		09 69 13	Access Flooring System	1.2														
			Access Flooring System	2.4														
			Operation and Maintenance Manuals	3.5														
		09 69 19	SD-02 Shop Drawings															
			Detailed Installation Drawings	1.4	G													
			SD-03 Product Data															
			Access Flooring System	2.4														
			SD-05 Design Data															
			Compliance with ICC-ES AC300	1.2														
			Seismic Calculations	1.2.6														
			SD-06 Test Reports															
			Electrical Resistance	3.2.2														
			Acceptance Tests	3.2.1														
			SD-07 Certificates															
			Certificate Of Compliance	1.2														
			Operation and Maintenance Manuals	3.5														
		09 72 00	SD-03 Product Data															
			Wallcoverings and Accessories	2.1	G													
			Primer and Adhesive	2.10														
			SD-07 Certificates															
			Manufacturer's Statement	2.1.2														
			SD-10 Operation and Maintenance Data															

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		09 72 00	Manufacturer's Maintenance Instructions	2.1.4														
		09 83 13	SD-02 Shop Drawings															
			Approved Detail Drawings	2.1	G													
			SD-03 Product Data															
			Installation	3.2														
			Acoustical Wall Panels	2.1	G													
			SD-04 Samples															
			Acoustical Wall Panels	2.1	G													
			SD-07 Certificates															
			Acoustical Wall Panels	2.1														
			SD-11 Closeout Submittals															
			LEED Documentation	1.2.1														
		09 90 00	SD-03 Product Data															
			Coating	3.6.4														
			Manufacturer's Technical Data Sheets	2.1														
			SD-07 Certificates															
			Applicator's qualifications	1.3														
			Qualification Testing	1.4.1.2														
			SD-08 Manufacturer’s Instructions															
			Application instructions	3.6.1														
			Mixing	3.6.2														
			Manufacturer's Material Safety Data Sheets	1.7.2														

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		09 90 00	SD-10 Operation and Maintenance															
			Data															
			Cleaning and Maintenance	3.13														
			Instructions															
		10 14 01	SD-02 Shop Drawings															
			Approved Detail Drawings	3.1														
			SD-03 Product Data															
			Exterior Signage	1.2														
			Wind Load Requirements	1.2.1														
		10 14 02	SD-02 Shop Drawings															
			Detail Drawings	1.2														
			SD-03 Product Data															
			Installation	3.1	G													
			SD-10 Operation and Maintenance															
			Data															
			Operating Instructions	3.1	G													
		10 21 13	SD-02 Shop Drawings															
			Installation Drawings	3.3														
			SD-03 Product Data															
			Hardware and Fittings	2.1.5														
			Warranty	1.6														
		10 26 13	SD-02 Shop Drawings															
			Corner Guards	2.2														
			Wall Guards (Bumper Guards)	2.3														
			Door Protectors	2.4														
			Wall Covering/Panels	2.5														

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		10 26 13	SD-03 Product Data														
			Corner Guards	2.2													
			Wall Guards (Bumper Guards)	2.3													
			Door Protectors	2.4													
			Wall Covering/Panels	2.5													
			SD-04 Samples														
			Finish	2.7													
			SD-06 Test Reports														
			Corner Guards	2.2													
			Wall Guards (Bumper Guards)	2.3													
			Door Protectors	2.4													
			Wall Covering/Panels	2.5													
			SD-07 Certificates														
			Corner Guards	2.2													
			Wall Guards (Bumper Guards)	2.3													
			Door Protectors	2.4													
			Wall Covering/Panels	2.5													
			SD-11 Closeout Submittals														
			LEED Documentation	1.2													
		10 28 13	SD-03 Product Data														
			Accessory Items	2.2	G												
			SD-10 Operation and Maintenance														
			Data														
			Electric Hand Dryer	2.2.27	G												
		11 68 13	SD-02 Shop Drawings														
			Configuration	2.2.1													

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		11 68 13	Shop Drawings	1.5.6														
			Fall Height	3.2.10														
			Finished Grade and Underground	3.1.1														
			Utilities															
			SD-03 Product Data															
			Equipment	2.2														
			Equipment Identification	1.3.4														
			Delivery, Storage and Handling	1.6														
			Manufacturer Qualification	1.5.1														
			Wood	2.1.2														
			Spare Parts	1.8														
			Materials	2.1														
			SD-04 Samples															
			Color	2.1.7														
			SD-06 Test Reports															
			Recycled Plastic	2.1.4														
			Wood Finishes	3.2.2														
			SD-07 Certificates															
			Materials	2.1														
			Manufacturer Qualification	1.5.1														
			Installer Qualification	1.5.2														
			Manufacturer's Representative	1.5.3														
			Wood Treatment	2.1.2.1														
			Substitution	2.2.2														
			Play Event Modification	3.2.1														

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		11 68 13	Child Safety and Accessibility	3.4														
			Evaluation															
			SD-10 Operation and Maintenance															
			Data															
			Maintenance Instructions	1.8														
		12 21 00	SD-03 Product Data															
			Window Blinds	2.1	G													
		12 32 00	SD-02 Shop Drawings															
			Installation Drawings	3.2														
			SD-03 Product Data															
			Cabinets	2.10														
			Accessories and Hardware	2.2														
			Countertops	2.10														
			Manufacturer's Standard Color	2.1														
			Charts															
			SD-08 Manufacturer’s Instructions															
			Manufacturer's Instructions	2.1														
		12 36 00	SD-02 Shop Drawings															
			Installation Drawings	3.1														
			SD-03 Product Data															
			Countertop	2.3	G													
			Joint Sealants	2.5.3	G													
			SD-08 Manufacturer’s Instructions															
			Manufacturer's Instructions	2.1	G													
		13 48 00.00 10	SD-02 Shop Drawings															
			Coupling and Bracing	3.1														

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		13 48 00.00 10	Flexible Couplings or Joints	3.3														
			Equipment Requirements	1.3														
			Contractor Designed Bracing	1.2.4	G													
			SD-03 Product Data															
			Coupling and Bracing	3.1	G													
			Equipment Requirements	1.3	G													
			Contractor Designed Bracing	1.2.4	G													
			SD-07 Certificates															
			Flexible Ball Joints	2.2														
		13 48 00	SD-02 Shop Drawings															
			Bracing	3.1	G													
			Resilient Vibration Isolation	3.4	G													
			Devices															
			Equipment Requirements	1.3	G													
			SD-03 Product Data															
			Bracing	3.1	G													
			Equipment Requirements	1.3	G													
			SD-06 Test Reports															
			Anchor Bolts	3.3														
		21 13 13.00 10	SD-02 Shop Drawings															
			Shop Drawings	1.4.3	G													
			As-Built Drawings	3.10														
			As-Built Drawings	3.10														
			SD-03 Product Data															
			Fire Protection Related	1.4.1	G													
			Submittals															

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		21 13 13.00 10	Materials and Equipment	2.3	G												
			Spare Parts	1.6													
			Onsite Training	3.11	G												
			SD-05 Design Data														
			Sway Bracing	1.4.3	G												
			Hydraulic Calculations	1.2.1.3	G												
			SD-06 Test Reports														
			Preliminary Tests	3.9	G												
			Preliminary Test Report	3.9	G												
			Final Acceptance Test	3.10	G												
			Final Acceptance Test Report	3.10	G												
			SD-07 Certificates														
			Fire Protection Specialist	1.4.1	G												
			Sprinkler System Installer	1.4.2	G												
			Inspection by Fire Protection	3.3	G												
			Specialist														
			SD-10 Operation and Maintenance														
			Data														
			Operating and Maintenance	3.11													
			Manuals														
		21 13 17.00 10	SD-02 Shop Drawings														
			Shop Drawings	1.4.3	G												
			As-Built Drawings	3.10													
			SD-03 Product Data														
			List of Submittals	1.4.1	G												
			Materials and Equipment	2.1	G												

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		21 13 17.00 10	Spare Parts	1.6														
			Onsite Training	3.11	G													
			SD-05 Design Data															
			Sway Bracing	3.5.1	G													
			Hydraulic Calculations	1.2.1.2	G													
			SD-06 Test Reports															
			Preliminary Tests	3.9	G													
			Final Acceptance Test	3.10	G													
			SD-07 Certificates															
			Fire Protection Specialist	1.4.1	G													
			Installer Qualifications	1.4.2	G													
			Inspection by Fire Protection	3.4	G													
			Specialist															
			SD-10 Operation and Maintenance															
			Data															
			Operating and Maintenance	3.11														
			Instructions															
		21 13 18.00 10	SD-02 Shop Drawings															
			Shop Drawings	1.4.3	G													
			As-Built Drawings	3.10														
			SD-03 Product Data															
			List of Submittals	1.4.1	G													
			Materials and Equipment	2.1	G													
			Spare Parts	1.6														
			Onsite Training	3.11	G													
			SD-05 Design Data															

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		21 13 18.00 10	Sway Bracing	3.5.1	G													
			Hydraulic Calculations	1.2.1.2	G													
			Storage Batteries	2.14.4.1	G													
			SD-06 Test Reports															
			Preliminary Tests	3.9	G													
			Final Acceptance Tests	3.10	G													
			SD-07 Certificates															
			Fire Protection Specialist	1.4.1	G													
			Installer Qualifications	1.4.2	G													
			Inspection by Fire Protection	3.4	G													
			Specialist															
			SD-10 Operation and Maintenance															
			Data															
			Operating and Maintenance	3.11														
			Instructions															
		21 13 24.00 10	SD-02 Shop Drawings															
			Detail Drawings	1.4.3	G													
			As-built Drawings	1.4.1														
			SD-03 Product Data															
			Materials and Equipment	2.1	G													
			Spare Parts	1.5														
			AFFF System	1.2	G													
			Installer's Qualifications	1.4.2	G													
			Post-discharge Test	3.7.4	G													
			Requirements															
			SD-06 Test Reports															

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		21 13 24.00 10	Test Reports	3.7.4	G													
			SD-07 Certificates															
			Materials and Equipment	2.1	G													
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.9	G													
			Manuals															
		21 21 03.00 10	SD-02 Shop Drawings															
			Installation Drawings	1.4.3	G													
			SD-03 Product Data															
			Similar Services	1.4														
			Standard Products	2.1	G													
			Field Training	3.4														
			SD-06 Test Reports															
			Preliminary Tests	3.2														
			Final Acceptance Tests	3.3														
			SD-07 Certificates															
			Installation Technician	1.4.2	G													
			Installation Drawings	1.4.3	G													
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.4														
			Instructions															
		21 30 00	SD-02 Shop Drawings															
			Installation Drawings	1.2	G													
			As-Built Drawings	3.9.5	G													

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		21 30 00	Piping Layout and Sensing Piping	1.2	G													
			Arrangement															
			Pump Room	1.2	G													
			SD-03 Product Data															
			Fire Pump Installation Related	3.2	G													
			Submittals															
			Catalog Data	2.1	G													
			Spare Parts	1.7	G													
			Field Training	3.11	G													
			SD-06 Test Reports															
			Field Tests	3.9	G													
			Preliminary Tests	3.9.2	G													
			Preliminary Tests	3.9.2	G													
			Army Final Acceptance Test	3.9.3	G													
			Army Final Acceptance Test	3.9.3	G													
			SD-07 Certificates															
			Fire Protection Specialist	1.4.1	G													
			Certification of Installation	3.9.3.9	G													
			Qualifications of Welders	1.4.2	G													
			Qualifications of Installer	1.4.3	G													
			Manufacturer's Representative	1.4.5	G													
			Preliminary Test Certification	1.4.4	G													
			SD-10 Operation and Maintenance															
			Data															
			Operating and Maintenance	3.11	G													
			Instructions															

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		21 30 00	Flow Meter	2.16	G													
		22 00 00	SD-02 Shop Drawings															
			Detail Drawings	1.9	G													
			SD-03 Product Data															
			Fixtures	2.4														
			Flush valve water closets	2.4.3														
			Flush valve urinals	2.4.4														
			Flush tank water closets	2.4.6														
			Wall hung lavatories	2.4.8														
			Countertop lavatories	2.4.9														
			Kitchen sinks	2.4.10														
			Service sinks	2.4.11														
			Drinking-water coolers	2.4.12	G													
			Bathtubs, Porcelain	2.4.17														
			Bathtubs, Cast Iron	2.4.16														
			Water heaters	2.10	G													
			Pumps	2.12	G													
			Backflow prevention assemblies	3.9.1.1	G													
			Shower Faucets	2.6.2	G													
			Swimming Pool and Spa Suction	2.6.9	G													
			Fittings															
			Pool Water Pump safety vacuum	2.15	G													
			release system															
			Welding	1.5.1														
			Vibration-Absorbing Features	3.4	G													
			Cast Iron Soil Pipe and Fittings	3.13														

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		22 00 00	SD-06 Test Reports														
			Tests, Flushing and Disinfection	3.9													
			Test of Backflow Prevention	3.9.1.1													
			Assemblies														
			Plumbing System	3.9.1													
			SD-07 Certificates														
			Materials and Equipment	1.3													
			Bolts	2.1.1													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.14	G												
			Manuals														
		22 31 00	SD-02 Shop Drawings														
			Installation	3.2													
			SD-03 Product Data														
			Softening Equipment	2.2													
			Spare Parts	1.4													
			Field Instructions	3.3.2													
			SD-06 Test Reports														
			Softening Equipment	2.2													
			Piping	3.4.2													
			SD-10 Operation and Maintenance														
			Data														
			Operating and Maintenance	3.3.2													
			Instructions														
		23 00 00	SD-02 Shop Drawings														

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		23 00 00	Detail Drawings	1.4.5	G													
			SD-03 Product Data															
			Metallic Flexible Duct	2.9.1.1														
			Insulated Nonmetallic Flexible	2.9.1.2														
			Duct Runouts															
			Duct Connectors	2.9.1.2														
			Duct Access Doors	2.9.2	G													
			Fire Dampers	2.9.3														
			Manual Balancing Dampers	2.9.4	G													
			Sound Attenuation Equipment	2.9.8														
			Acoustical Duct Liner	2.9.8														
			Diffusers	2.9.9.1														
			Perforated Plate Diffusers	2.9.9.2														
			Linear Diffusers	2.9.9.3														
			Security Ceiling Diffusers	2.9.9.4														
			Registers and Grilles	2.9.9.5														
			Louvers	2.9.10														
			Air Vents, Penthouses, and	2.9.11														
			Goosenecks															
			Centrifugal Fans	2.10.1.1	G													
			In-Line Centrifugal Fans	2.10.1.2	G													
			Axial Flow Fans	2.10.1.3	G													
			Panel Type Power Wall	2.10.1.4	G													
			Ventilators															
			Centrifugal Type Power Wall	2.10.1.5	G													
			Ventilators															

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		23 00 00	Centrifugal Type Power Roof	2.10.1.6	G													
			Ventilators															
			Propeller Type Power Roof	2.10.1.7	G													
			Ventilators															
			Air-Curtain Fans	2.10.1.8	G													
			Ceiling Exhaust Fans	2.10.1.9	G													
			Air Handling Units	2.11	G													
			Room Fan-Coil Units	2.12.1	G													
			Coil Induction Units	2.12.2	G													
			Constant Volume, Single Duct	2.12.3.1	G													
			Terminal Units															
			Variable Volume, Single Duct	2.12.3.2	G													
			Terminal Units															
			Variable Volume, Single Duct,	2.12.3.3	G													
			Fan-Powered Terminal Units															
			Dual Duct Terminal Units	2.12.3.4	G													
			Ceiling Induction Terminal Units	2.12.3.5	G													
			Reheat Units	2.12.3.7	G													
			Unit Ventilators	2.12.4	G													
			Energy Recovery Devices	2.13	G													
			Test Procedures	1.4.6														
			Diagrams	1.2.1.2														
			SD-06 Test Reports															
			Performance Tests	3.12														
			Damper Acceptance Test	3.10														
			SD-08 Manufacturer’s Instructions															

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		23 00 00	Manufacturer's Installation	3.2														
			Instructions															
			Operation and Maintenance	3.14.2														
			Training															
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.14.1	G													
			Manuals															
		23 03 00.00 20	SD-03 Product Data															
			Certification	1.4.5.3														
		23 05 93	SD-01 Preconstruction Submittals															
			Records of Existing Conditions	1.3	G													
			Records of Existing Conditions	1.3.3	G													
			TAB Firm	1.5.3.1	G													
			TAB team assistants	1.2	G													
			TAB team engineer	1.2	G													
			TAB Specialist	1.5.3.2	G													
			TAB team field leader	1.2	G													
			SD-02 Shop Drawings															
			TAB Schematic Drawings and	1.3.3	G													
			Report Forms															
			SD-03 Product Data															
			Equipment and Performance	1.3	G													
			Data															
			TAB Related HVAC Submittals	1.5.3.4	G													
			TAB Procedures	1.5.2	G													

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		23 05 93	Calibration	1.5.2	G												
			Systems Readiness Check	1.3.3	G												
			TAB Execution	1.5.4	G												
			TAB Verification	1.5.4.3	G												
			SD-06 Test Reports														
			Design review report	1.3.3	G												
			Design review report	1.7.2.1	G												
			Pre-Final DALT report	1.7.2	G												
			Pre-Final DALT report	3.3.5	G												
			Final DALT report	1.7.2	G												
			Final DALT report	3.3.8	G												
			TAB report for Season 1	1.5.5.2	G												
			TAB report for Season 2	1.5.5.2	G												
			SD-07 Certificates														
			TAB Firm	1.5.3.1	G												
			Independent TAB Agency and	1.5.1	G												
			Personnel Qualifications														
			DALT and TAB Submittal and	1.7.2	G												
			Work Schedule														
			Design review report	1.3.3	G												
			Design review report	1.7.2.1	G												
			Pre-field DALT preliminary	1.7.2.2	G												
			notification														
			Pre-field TAB engineering report	1.7.2.3	G												
			Advanced notice for Season 1	1.7.2	G												
			TAB field work														

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		23 05 93	Prerequisite HVAC Work Check	1.7.2	G												
			Out List For Season 1														
		23 07 00	SD-02 Shop Drawings														
			MICA Plates	3.2.2.4	G												
			Pipe Insulation Systems	2.3	G												
			Pipe Insulation Systems	3.2	G												
			Duct Insulation Systems	3.3	G												
			Equipment Insulation Systems	3.4	G												
			SD-03 Product Data														
			Pipe Insulation Systems	2.3	G												
			Pipe Insulation Systems	3.2	G												
			Duct Insulation Systems	3.3	G												
			Equipment Insulation Systems	3.4	G												
			SD-08 Manufacturer’s Instructions														
			Pipe Insulation Systems	2.3	G												
			Pipe Insulation Systems	3.2	G												
			Duct Insulation Systems	3.3	G												
			Equipment Insulation Systems	3.4	G												
		23 08 00.00 10	SD-02 Shop Drawings														
			Commissioning Plan	1.5.2.2	G												
			SD-03 Product Data														
			Pre-Functional Performance Test	3.2.1	G												
			Checklists														
			Functional Performance Tests	3.2.2	G												
			SD-06 Test Reports														
			Commissioning Report	3.3	G												

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		23 08 00.00 10	SD-07 Certificates															
			Commissioning Firm	1.5.1	G													
			Commissioning Specialist	1.5.2	G													
		23 09 23.13 20	SD-02 Shop Drawings															
			Control system drawings title sheet	1.4.1.1	G													
			List of I/O Points	1.4.1.2	G													
			Control System Components List	1.4.1.3	G													
			Control system schematics	1.4.1.4	G													
			HVAC Equipment Electrical Ladder diagrams	1.4.1.5	G													
			Component wiring diagrams	1.4.1.6	G													
			Terminal strip diagrams	1.4.1.7	G													
			BACnet communication architecture schematic	1.4.1.8	G													
			SD-03 Product Data															
			Direct Digital Controllers	2.1.1	G													
			BACnet Gateways	2.1.1.13	G													
			BACnet Protocol Analyzer	2.1.5	G													
			DDC Software	2.1.2	G													
			BACnet Operator Workstation	2.1.3	G													
			BACnet Operator Workstation DDC Software	2.1.3.3	G													
			Notebook Computer	2.1.4	G													
			Sensors and Input Hardware	2.2	G													
			Output Hardware	2.3	G													

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							CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY				
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		23 09 23.13 20	Surge and transient protection	2.4.2	G													
			Indicators	2.6	G													
			Air compressors	2.7.1	G													
			Refrigerated air dryers	2.7.2	G													
			Pneumatic tubing	2.7.6	G													
			Duct smoke detectors	2.5.1	G													
			Variable frequency (motor) drives	2.8	G													
			SD-05 Design Data															
			Performance Verification Testing	3.4.2	G													
			Plan															
			Pre-Performance Verification	3.4.4	G													
			Testing Checklist															
			SD-06 Test Reports															
			Performance Verification Testing	3.4.11	G													
			Report															
			SD-07 Certificates															
			Contractor's Qualifications	1.6.6	G													
			SD-09 Manufacturer's Field															
			Reports															
			Pre-PVT Checklist	3.4.1	G													
			SD-10 Operation and Maintenance															
			Data															
			BACnet Direct Digital Control	1.4	G													
			Systems															
			Controls System Operators	3.3	G													
			Manuals															

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		23 09 23.13 20	VFD Service Manuals	2.8.2	G													
			SD-11 Closeout Submittals															
			Training documentation	3.5.1	G													
		23 09 23	SD-02 Shop Drawings															
			DDC Contractor Design Drawings	3.3.1	G													
			Draft As-Built Drawings	3.3.2	G													
			Final As-Built Drawings	3.3.3	G													
			SD-03 Product Data															
			Manufacturer's Catalog Data	2.1.1	G													
			Manufacturer's Catalog Data	2.14.1	G													
			Programming Software	2.14.5	G													
			GPPC Application Programs	2.14.5	G													
			AGC Application Programs	2.14.6	G													
			XIF files	2.14.1	G													
			Draft LNS Database	3.6.2	G													
			Final LNS Database	1.3.1	G													
			Final LNS Database	3.7.4	G													
			LNS Plug-in	2.14.4	G													
			LNS Plug-in	2.14.6	G													
			SD-06 Test Reports															
			Existing Conditions Report	3.1	G													
			Start-Up and Start-Up Testing Report	3.6.1	G													
			PVT Procedures	3.7.1	G													
			PVT Report	3.7.3	G													
			Pre-Construction QC Checklist	1.6	G													

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		23 09 23	Post-Construction QC Checklist	1.6	G													
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	1.8	G													
			(O&M) Instructions															
			Training Documentation	3.9.1	G													
			SD-11 Closeout Submittals															
			Closeout QC Checklist	1.6	G													
		23 09 53.00 20	SD-02 Shop Drawings															
			Control system diagrams	1.6.1	G													
			Ladder diagram	1.6.2	G													
			Operating parameters	1.6.3	G													
			Automatic control valve	1.6.4	G													
			schedules															
			Damper schedules	1.6.5	G													
			Sequence of operation	1.6.8	G													
			Arrangement drawing	1.6.9	G													
			Wiring diagram	1.6.6	G													
			Compressed air station schematic	1.6.7	G													
			Control panel schematics	1.6.7	G													
			SD-03 Product Data															
			Actuators	2.2	G													
			Valves	2.3	G													
			Dampers	2.4	G													
			Fire protection devices	2.5	G													
			Sensors	2.6	G													

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		23 09 53.00 20	Thermostats	2.8	G													
			Sunshields	2.9	G													
			Pressure switches	2.10.1	G													
			Indicating devices	2.11	G													
			Controllers	2.13	G													
			Pressure gages	2.12	G													
			Control panels	2.15	G													
			Air Compressor	2.16.1	G													
			Refrigerated air dryer	2.16.2	G													
			Air filtration system	2.16.2	G													
			Compressed air station	2.16.2	G													
			specialties															
			VAV Terminal unit controls	2.17	G													
			SD-06 Test Reports															
			Commissioning procedures	1.8.6	G													
			Calibration adjustment and	1.8.7	G													
			commissioning reports															
			Site testing procedures	1.8.5	G													
			Performance verification test	3.3.5	G													
			SD-07 Certificates															
			Certification of completion	3.3.4														
			SD-08 Manufacturer’s Instructions															
			Training course documentation	3.4.1														
			SD-10 Operation and Maintenance															
			Data															

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		23 09 53.00 20	Space temperature control system	1.8.8	G													
			SD-11 Closeout Submittals															
			Qualified service organization list	3.5														
		23 11 25	SD-02 Shop Drawings															
			Gas Piping System	1.4.3	G													
			Gas Piping System	2.2	G													
			Gas Piping System	3.3	G													
			SD-03 Product Data															
			Pipe and Fittings	1.5	G													
			Gas equipment connectors	1.4.3	G													
			Gas Piping System	1.4.3	G													
			Gas Piping System	2.2	G													
			Gas Piping System	3.3	G													
			Pipe Coating Materials	2.1	G													
			Pressure regulators	2.6	G													
			Risers	2.4	G													
			Transition fittings	2.2.12	G													
			Valves	2.3	G													
			Valve box	2.6	G													
			Warning and identification tape	2.2.8	G													
			SD-06 Test Reports															
			Testing	3.16														
			Pressure Tests	3.16.1														
			Pressure Tests for Liquefied Petroleum Gas	3.16.1														

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		23 11 25	Test With Gas	3.16.2													
			SD-07 Certificates														
			Welders procedures and qualifications	1.4.1													
			assigned number, letter, or symbol	1.4.1													
			SD-08 Manufacturer’s Instructions														
			PE pipe and fittings	1.4.2	G												
			pipe coating materials	2.1	G												
			SD-10 Operation and Maintenance Data														
			Gas facility system and equipment operation	1.2.1	G												
			Gas facility system maintenance	1.2.2	G												
			Gas facility equipment maintenance	1.2.3	G												
		23 23 00	SD-02 Shop Drawings														
			Refrigerant Piping System	2.3	G												
			SD-03 Product Data														
			Refrigerant Piping System	2.3													
			Spare Parts	1.5.2													
			Qualifications	1.3.1	G												
			Refrigerant Piping Tests	3.5	G												
			Demonstrations	3.4	G												
			Demonstrations	3.6	G												
			Verification of Dimensions	3.1													

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		23 23 00	SD-06 Test Reports															
			Refrigerant Piping Tests	3.5														
			SD-07 Certificates															
			Service Organization	2.1	G													
			SD-10 Operation and Maintenance															
			Data															
			Maintenance	1.5														
			Operation and Maintenance	3.4														
			Manuals															
		23 52 00	SD-02 Shop Drawings															
			Detail Drawings	1.5														
			SD-03 Product Data															
			Materials and Equipment	2.1.1														
			Spare Parts	1.5														
			Water Treatment System	2.17														
			Boiler Water Treatment	2.17														
			Heating System Tests	3.10														
			Fuel System Tests	3.13														
			Unit Heaters	2.9														
			Welding	1.3														
			Qualifications	3.10														
			Field Instructions	3.12														
			Tests	3.4														
			SD-06 Test Reports															
			Heating System Tests	3.10														
			Fuel System Tests	3.13														

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		23 52 00	Water Treatment Testing	3.10.1														
			SD-07 Certificates															
			Bolts	2.12.12.3														
			Continuous Emissions Monitoring	2.12.2														
			Energy Star	2.1.3														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.12														
			Instructions															
			Water Treatment System	2.17														
		23 57 10.00 10	SD-02 Shop Drawings															
			Heating System	2.17														
			SD-03 Product Data															
			Spare Parts	1.5														
			Welding	3.4														
			Framed Instructions	3.19														
			SD-06 Test Reports															
			Testing and Cleaning	3.18														
			Water Treatment Testing	3.18.4														
			SD-07 Certificates															
			Bolts	2.2.9.3														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.20														
			Manuals															
		23 63 00.00 10	SD-02 Shop Drawings															

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		23 63 00.00 10	Drawings	1.3.2	G													
			SD-03 Product Data															
			Refrigeration System	2.10	G													
			Spare Parts	1.5.3														
			Framed Instructions	3.2.23														
			Qualifications	1.3.1	G													
			Verification of Dimensions	3.1														
			Coil Corrosion Protection	2.22.1														
			Tests	3.3														
			Demonstrations	3.4	G													
			SD-06 Test Reports															
			Tests	3.3	G													
			SD-07 Certificates															
			Refrigeration System	2.10														
			Service Organizations	1.3.3														
		23 64 00	SD-02 Shop Drawings															
			Drawings	1.5.2	G													
			SD-03 Product Data															
			Absorption Water Chiller	3.4.1	G													
			Absorption Water Chiller	3.4.1	G													
			Absorption Water Chiller	3.4.2	G													
			Absorption Water Chiller	3.4.2	G													
			Posted Instructions	3.6	G													
			Verification of Dimensions	1.5.1	G													
			System Performance Tests	3.5	G													
			Demonstrations	3.6														

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(a)	(b)	(c)	(d)	(e)	(f)		(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 64 00	SD-06 Test Reports															
			Field Acceptance Testing	3.4														
			Absorption water chiller	3.4.1														
			Absorption water chiller	3.4.2														
			System Performance Tests	3.5														
			SD-07 Certificates															
			Absorption Water Chiller	3.4.1	G													
			Absorption Water Chiller	3.4.2	G													
			SD-08 Manufacturer’s Instructions															
			Water chiller	3.1														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.6														
			Manuals															
		23 64 10	SD-03 Product Data															
			Water Chiller	2.5	G													
			Water Chiller	2.5	G													
			Water Chiller	3.1	G													
			Water Chiller	3.1	G													
			Water Chiller	3.4.1	G													
			Water Chiller	3.4.1	G													
			Water Chiller	3.4.2	G													
			Water Chiller	3.4.2	G													
			Posted Instructions	3.6														
			Verification of Dimensions	1.5.1														

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		23 64 10	Manufacturer's Multi-Year	1.7														
			Compressor Warranty															
			Factory Tests	2.9														
			System Performance Tests	3.5														
			Demonstrations	3.6														
			SD-06 Test Reports															
			Field Acceptance Testing	3.4														
			Water Chiller	2.5														
			Water Chiller	3.1														
			Water Chiller	3.4.1														
			Water Chiller	3.4.2														
			Factory Tests	2.9														
			System Performance Tests	3.5														
			SD-07 Certificates															
			Refrigeration System	3.1.2	G													
			SD-08 Manufacturer’s Instructions															
			Water Chiller	2.5	G													
			Water Chiller	3.1	G													
			Water Chiller	3.4.1	G													
			Water Chiller	3.4.2	G													
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.6	G													
			Manuals															
		23 64 26	SD-03 Product Data															

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		23 64 26	Grooved Mechanical Connections	2.2.2.4	G													
			For Steel															
			Grooved Mechanical Connections	2.5.3	G													
			For Copper															
			Calibrated Balancing Valves	2.6.8	G													
			Automatic Flow Control Valves	2.6.9	G													
			Pump Discharge Valve	2.6.10														
			Water Temperature Mixing Valve	2.6.11	G													
			Water Temperature Regulating	2.6.12	G													
			Valves															
			Water Pressure Reducing Valve	2.6.13														
			Pressure Relief Valve	2.6.14														
			Combination Pressure and	2.6.15														
			Temperature Relief Valves															
			Expansion Joints	2.7.9	G													
			Pumps	2.8	G													
			Combination Strainer and Pump	2.7.3														
			Suction Diffuser															
			Expansion Tanks	2.9														
			Air Separator Tanks	2.10														
			Water Treatment Systems	2.11	G													
			SD-06 Test Reports															
			Piping welds NDE report	3.1.1.3														
			Pressure tests reports	3.4.2	G													
			Condenser Water Quality Test	3.4.3	G													
			Reports															

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		23 64 26	Condenser Water Quality Test	3.4.3	G													
			Reports															
			One-Year Inspection Report For	3.6	G													
			Cooling Water															
			SD-07 Certificates															
			Employer's Record Documents	3.1.1.1														
			(For Welding)															
			Welding Procedures and	3.1.1.2														
			Qualifications															
			Piping for Steam and Condensate	2.3														
			Piping for High-Pressure	2.4														
			Compressed-Air Systems															
			Fittings	2.3														
			Fittings	2.4														
			Unions	2.3														
			Unions	2.4														
			Flanges	2.3														
			Flanges	2.4														
			Gaskets	2.3														
			Gaskets	2.4														
			Bolting	2.3														
			Bolting	2.4														
			SD-08 Manufacturer’s Instructions															
			Lesson plan for the Instruction	3.5	G													
			Course															

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		23 64 26	SD-10 Operation and Maintenance															
			Data															
			Water Treatment Systems	2.11	G													
			Calibrated Balancing Valves	2.6.8	G													
			Automatic Flow Control Valves	2.6.9	G													
			Pump Discharge Valve	2.6.10	G													
			Water Temperature Mixing Valve	2.6.11	G													
			Water Temperature Regulating	2.6.12	G													
			Valves															
			Water Pressure Reducing Valve	2.6.13	G													
			Pressure Relief Valve	2.6.14	G													
			Combination Pressure and	2.6.15	G													
			Temperature Relief Valves															
			Expansion Joints	2.7.9	G													
			Pumps	2.8	G													
			Combination Strainer and Pump	2.7.3	G													
			Suction Diffuser															
			Expansion Tanks	2.9	G													
			Air Separator Tanks	2.10	G													
		23 65 00	SD-03 Product Data															
			Cooling Towers	2.5	G													
			Posted Instructions	3.1	G													
			Demonstrations	3.1	G													
			Verification of Dimensions	1.5.1	G													
			SD-06 Test Reports															

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		23 65 00	Packaged cooling tower -	3.2	G												
			installation instructions														
			Field-erected cooling tower -	3.2	G												
			installation instructions														
			Packaged cooling tower - field	3.3.1	G												
			acceptance test plan														
			Field-erected cooling tower - field	3.3.1	G												
			acceptance test plan														
			Packaged cooling tower - field	3.4	G												
			acceptance test report														
			Field-erected cooling tower - field	3.4	G												
			acceptance test report														
			SD-07 Certificates														
			Service Organization	2.1													
			Cooling Tower	2.5.1.12													
			SD-08 Manufacturer’s Instructions														
			Packaged cooling tower -	3.2													
			installation instructions														
			Field-erected cooling tower -	3.2													
			installation instructions														
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.1													
			Manuals														
		23 82 01.00 10	SD-02 Shop Drawings														
			Installation	3.2	G												

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		23 82 01.00 10	SD-03 Product Data															
			Spare Parts	1.6														
			Furnace	2.2														
			Tests	3.6														
			System Diagrams	3.6	G													
			Qualifications	1.4														
			Field Training	3.5														
			SD-06 Test Reports															
			Tests	3.6														
			SD-10 Operation and Maintenance															
			Data															
			Operating and Maintenance	3.5														
			Manuals															
		23 82 02.00 10	SD-02 Shop Drawings															
			Drawings	1.4														
			SD-03 Product Data															
			Materials and Equipment	2.1														
			Spare Parts	1.6														
			Posted Instructions	3.4														
			Verification of Dimensions	3.1														
			Coil Corrosion Protection	2.10.1.1														
			System Performance Tests	3.6														
			Demonstrations	3.4														
			SD-06 Test Reports															
			Refrigerant Tests, Charging, and	3.5														
			Start-Up															

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		23 82 02.00 10	System Performance Tests	3.6														
			SD-07 Certificates															
			Materials and Equipment	2.1														
			Service Organization	2.1.1														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.4														
			Manuals															
		25 08 10	SD-01 Preconstruction Submittals															
			Factory Test	3.4	G													
			SD-06 Test Reports															
			UMCS and Building Level DDC	3.1														
			Testing Sequence															
			Performance Verification Test	3.6	G													
			Endurance Testing	3.7														
		25 10 10	SD-02 Shop Drawings															
			UMCS Contractor Design	3.3.2	G													
			Drawings															
			Draft As-Built Drawings	3.3.3	G													
			Final As-Built Drawings	3.3.3	G													
			SD-03 Product Data															
			Product Data Sheets	2.1.4	G													
			Computer Software	2.4	G													
			SD-05 Design Data															
			Network Bandwidth Usage	3.3.1	G													
			Calculations															

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		25 10 10	SD-06 Test Reports															
			Existing Conditions Report	3.2														
			Factory Test Procedures	3.1														
			Factory Test Report	3.1														
			Start-Up and Start-Up Testing	3.7														
			Report															
			PVT Phase I Procedures	3.8.1														
			PVT Phase I Report	3.8.2														
			PVT Phase II Report	3.8.3														
			Pre-Construction QC Checklist	1.6														
			Post-Construction QC Checklist	1.6														
			SD-10 Operation and Maintenance															
			Data															
			Preventive Maintenance Work	3.9.8.1	G													
			Plan															
			Basic Operator Training	3.10.1	G													
			Documentation															
			Advanced Operator Training	3.10.1	G													
			Documentation															
			Operator Refresher Training	3.10.1	G													
			Documentation															
			Operation and Maintenance	1.7	G													
			(O&M) Instructions															
			SD-11 Closeout Submittals															
			Closeout QC Checklist	1.6	G													
		26 05 48.00 10	SD-02 Shop Drawings															

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		26 05 48.00 10	Lighting Fixtures in Buildings	3.2														
			Equipment Requirements	1.3														
			SD-03 Product Data															
			Lighting Fixtures in Buildings	3.2	G													
			Equipment Requirements	1.3	G													
			Contractor Designed Bracing	1.2.4	G													
		26 08 00	SD-06 Test Reports															
			Acceptance tests and inspections	3.1														
			SD-07 Certificates															
			Qualifications	1.4.1	G													
			Acceptance test and inspections	1.4.3	G													
			procedure															
		26 20 00	SD-02 Shop Drawings															
			Motor control centers	2.23														
			SD-03 Product Data															
			Transformers	2.19	G													
			Motor controllers	2.21	G													
			Metering	2.34														
			CATV outlets	2.26.1														
			Surge protective devices	2.36														
			SD-06 Test Reports															
			600-volt wiring test	3.5.2														
			Grounding system test	3.5.5														
			Transformer tests	3.5.3														
			SD-09 Manufacturer's Field															
			Reports															

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		26 20 00	Transformer factory tests	2.38.1														
			SD-10 Operation and Maintenance Data															
			Electrical Systems	1.5.1														
			Metering	2.34														
		26 23 00	SD-02 Shop Drawings															
			Switchboard / Switchgear Drawings	1.5.2	G													
			SD-03 Product Data															
			Switchboard / Switchgear	2.2	G													
			SD-06 Test Reports															
			Switchboard / Switchgear design tests	2.5.2														
			Switchboard / Switchgear production tests	2.5.3														
			Acceptance checks and tests	3.5.1	G													
			SD-10 Operation and Maintenance Data															
			Switchboard / Switchgear Operation and Maintenance	1.6.1	G													
			SD-11 Closeout Submittals															
			Assembled Operation and Maintenance Manuals	1.6.2														
			Equipment Test Schedule	2.5.1	G													
			Request for Settings	3.5	G													
		26 28 01.00 10	SD-03 Product Data															

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		26 28 01.00 10	Fault Current Analysis	2.14														
			Protective Device Coordination	2.14														
			Study															
			Equipment	2.1														
			System Coordinator	1.4.1														
			Protective Relays	3.3.5														
			Installation	3.2														
			SD-06 Test Reports															
			Field Testing	3.3														
			SD-07 Certificates															
			Devices and Equipment	1.6														
		26 32 14.00 10	SD-02 Shop Drawings															
			Detailed Drawings	1.4.6	G													
			Acceptance	3.11	G													
			SD-03 Product Data															
			Manufacturer's Catalog	2.4														
			Instructions	3.10														
			Experience	1.4.3														
			Field Engineer	1.4.4														
			Site Welding	1.4.2														
			General Installation	3.2														
			Site Visit	3.1														
			SD-05 Design Data															
			Sound Limitations	2.8														
			Generator	2.14														
			Integral Main Fuel Storage Tank	2.5.4														

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		26 32 14.00 10	Power Factor	3.6.2.2													
			Heat Exchanger	2.7.2													
			Time-Delay on Alarms	2.18.5													
			Cooling System	2.7													
			Vibration Isolation	1.2.5													
			SD-06 Test Reports														
			Performance Tests	3.6.6													
			Onsite Inspection and Tests	3.6	G												
			SD-07 Certificates														
			Vibration Isolation	1.2.5													
			Prototype Tests	3.4													
			Reliability and Durability	1.2.6													
			Emissions	2.11													
			Sound limitations	2.8													
			Current Balance	2.14.1													
			Materials and Equipment	2.3													
			Factory Inspection and Tests	2.27													
			Inspections	3.6.4													
			Cooling System	2.7													
			SD-10 Operation and Maintenance														
			Data														
			Operation Manual	1.6.1													
			Maintenance Manual	1.6.2													
			Extra Materials	1.6.3													
		26 36 00.00 10	SD-02 Shop Drawings														
			Detail Drawings	1.3.1													

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ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		26 36 00.00 10	Installation	3.1													
			SD-03 Product Data														
			Equipment	2.1													
			SD-06 Test Reports														
			Testing	2.6													
			SD-10 Operation and Maintenance														
			Data														
			Switching Equipment	1.3.2													
			Instructions	3.2													
		26 41 00	SD-02 Shop Drawings														
			Overall lightning protection	1.4.1.1	G												
			system														
			Each major component	1.4.1.2	G												
			SD-06 Test Reports														
			Lightning Protection and	1.4.3	G												
			Grounding System Test Plan														
			Lightning Protection and	3.5.1	G												
			Grounding System Test														
			SD-07 Certificates														
			Lightning Protection System	1.2.3	G												
			Installers Documentation														
			Component UL Listed and	1.4.2	G												
			Labeled														
			Lightning protection system	1.4.4	G												
			inspection certificate														
			Roof manufacturer's warranty	3.1.1	G												

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		26 42 14.00 10	SD-02 Shop Drawings															
			Drawings	1.4.6	G													
			Contractor's Modifications	1.2.1	G													
			SD-03 Product Data															
			Equipment	1.2	G													
			Spare Parts	1.6														
			SD-06 Test Reports															
			Tests and Measurements	3.5														
			Contractor's Modifications	1.2.1														
			SD-07 Certificates															
			Cathodic Protection System	1.2														
			Services of 'Corrosion Expert'	1.4.1	G													
			SD-10 Operation and Maintenance															
			Data															
			Cathodic Protection System	1.2														
			Training Course	3.6														
		26 42 17.00 10	SD-02 Shop Drawings															
			Detail Drawings	1.2.1	G													
			Contractor's Modifications	1.2.2	G													
			SD-03 Product Data															
			Miscellaneous Materials	2.4														
			Spare Parts	1.6														
			SD-06 Test Reports															
			Tests and Measurements	3.6														
			Contractor's Modifications	1.2.2														
			SD-07 Certificates															

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		26 42 17.00 10	Tests and Measurements	3.6													
			Cathodic Protection System	1.2.1													
			Services of 'Corrosion Expert'	1.4.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Cathodic Protection System	1.2.1													
			Training Course	3.5													
		26 51 00	SD-03 Product Data														
			Fluorescent lighting fixtures	2.1													
			Fluorescent electronic ballasts	1.6.1													
			Fluorescent lamps	2.1.5													
			Metal-halide lamps	2.2.2	G												
			Exit signs	2.11													
			Emergency lighting equipment	2.12	G												
			Central emergency system	2.14	G												
			Occupancy sensors	2.15													
			Electronic dimming ballast	2.1.2													
			Dimming ballast controls	2.1.3													
			Energy Efficiency	1.6.3.3													
			SD-06 Test Reports														
			Operating test	3.3													
		26 56 00	SD-01 Preconstruction Submittals														
			Photometric Plan	1.5.3	G												
			LED Luminaire Warranty	1.7.1	G												
			SD-02 Shop Drawings														
			Luminaire drawings	1.5.1.1	G												

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		26 56 00	Poles	1.5.1.2	G													
			SD-03 Product Data															
			Luminaire Light Sources	2.2.2	G													
			Fluorescent, Induction and LED	2.2	G													
			Luminaires															
			Luminaire Ballasts, Generators	2.2.3	G													
			and Power Supply Units (Drivers)															
			Lighting contactor	2.3.3	G													
			Time switch	2.3.2	G													
			Lighting Control Relay Panel	2.3.4	G													
			Motion Sensor	2.3.5	G													
			Photocell	2.3.1	G													
			Concrete poles	2.4.1	G													
			Aluminum poles	2.4.2	G													
			Steel poles	2.4.3	G													
			Fiberglass poles	2.4.4	G													
			Brackets	2.5														
			SD-05 Design Data															
			Design Data for luminaires	1.5.4	G													
			SD-06 Test Reports															
			LED Luminaire - IES LM-79 Test	1.5.5	G													
			Report															
			LED Light Source - IES LM-80	1.5.6	G													
			Test Report															
			Operating test	3.2														
			SD-07 Certificates															

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		26 56 00	Luminaire Useful Life Certificate	1.7.1	G												
			SD-08 Manufacturer's Instructions														
			Concrete poles	2.4.1													
			Fiberglass poles	2.4.4													
			SD-10 Operation and Maintenance														
			Data														
			Electronic Ballast Warranty	1.7.2													
		26 56 20.00 10	SD-02 Shop Drawings														
			Lighting and Visual Navigation	2.1	G												
			Aids														
			As-Built Drawings	1.3.5	G												
			SD-03 Product Data														
			Materials and Equipment	2.2	G												
			Protection Plan	1.3.3													
			Training	3.26													
			Special Tools	3.26													
			List of Parts	3.26													
			Maintenance and Repair	3.26													
			Posted Instructions	3.28	G												
			SD-06 Test Reports														
			Field Quality Control	3.24													
			Visual Inspection	3.24.3													
			SD-07 Certificates														
			Qualifications	1.3.2													
			Materials and Equipment	2.2	G												

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		26 56 20.00 10	SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.26													
			Procedures														
		27 10 00	SD-02 Shop Drawings														
			Telecommunications drawings	1.6.1.1	G												
			Telecommunications Space	1.6.1.2	G												
			Drawings														
			SD-03 Product Data														
			Telecommunications cabling	2.3	G												
			Patch panels	2.4.5	G												
			Telecommunications	2.5	G												
			outlet/connector assemblies														
			Equipment support frame	2.4.2	G												
			Connector blocks	2.4.3	G												
			Spare Parts	1.10.3													
			SD-06 Test Reports														
			Telecommunications cabling	3.5.1	G												
			testing														
			SD-07 Certificates														
			Telecommunications Contractor	1.6.2.1	G												
			Key Personnel	1.6.2.2	G												
			Manufacturer Qualifications	1.6.2.3	G												
			Test plan	1.6.3	G												
			SD-09 Manufacturer’s Field														
			Reports														

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		27 10 00	Factory reel tests	2.12.1	G													
			SD-10 Operation and Maintenance Data															
			Telecommunications cabling and pathway system	1.10.1	G													
			SD-11 Closeout Submittals															
			Record Documentation	1.10.2	G													
		27 54 00.00 20	SD-02 Shop Drawings															
			wiring diagrams and installation details	1.6.1														
			SD-03 Product Data															
			Amplifiers	2.2.1														
			Cables	2.2.2														
			Terminators	2.2.3														
			Splitters	2.2.4														
			Outlets	2.2.5														
			Connectors	2.2.6														
			Grounding block	2.3.1														
			SD-05 Design Data															
			CATV System Loss Calculations	1.6.2														
			SD-06 Test Reports															
			Acceptance tests	3.2.2														
		28 31 33.00 10	SD-02 Shop Drawings															
			Fire Alarm Reporting System	1.2	G													
			Wiring for Systems	3.2.2														
			SD-03 Product Data															

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		28 31 33.00 10	Battery	2.3.2.1														
			Spare Parts	1.6														
			Training	3.5														
			Test Procedures	3.6														
			SD-06 Test Reports															
			Testing	3.6														
			SD-07 Certificates															
			Equipment	1.6														
			Qualifications	1.4														
			SD-10 Operation and Maintenance															
			Data															
			Fire Alarm Reporting System	1.2														
		28 31 49	SD-03 Product Data															
			Carbon monoxide detector	2.1	G													
			SD-06 Test Reports															
			Carbon monoxide detector test	3.2.1														
			SD-10 Operation and Maintenance															
			Data															
			As-Built Drawings	3.2.2														
		28 31 64.00 10	SD-02 Shop Drawings															
			Detail Drawings	1.4.2	G													
			SD-03 Product Data															
			Special Tools and Spare Parts	1.7														
			Battery Calculations	2.4	G													
			SD-06 Test Reports															
			Testing	3.7														

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		28 31 64.00 10	SD-07 Certificates															
			Qualifications	1.4.1														
			SD-10 Operation and Maintenance Data															
			Technical Data and Computer Software	1.5														
			Operating and Maintenance Instructions	3.6														
		28 31 76	SD-02 Shop Drawings															
			Wiring Diagrams	3.2.1	G													
			System Layout	1.4.1	G													
			System Operation	2.3	G													
			SD-03 Product Data															
			Fire Alarm Control Unit and Mass Notification Control Unit (FMCP)	2.14	G													
			Manual stations	2.18														
			Transmitters	2.22	G													
			Batteries	2.13.1	G													
			Battery chargers	2.13.2	G													
			Smoke sensors	2.10														
			Heat detectors	2.11														
			Notification appliances	2.19														
			Addressable interface devices	2.7														
			Amplifiers	2.16														
			Remote Fire Alarm/Mass Notification Control Units	2.15	G													

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		28 31 76	Radio transmitter and interface	2.22.1														
			panels															
			Local Operating Console (LOC)	2.14.5.2														
			SD-05 Design Data															
			Battery Power Calculations	2.13.1.2														
			SD-06 Test Reports															
			Field Quality Control	3.7														
			Testing Procedures	3.7.1														
			Final Testing	3.7.2.3														
			SD-07 Certificates															
			Qualifications	1.6.1														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	1.8														
			(O&M) Instructions															
			Instruction of Government	3.8														
			Employees															
			SD-11 Closeout Submittals															
			As-Built Drawings	3.7.2.4														
			As-Built Drawings	3.7.2.4														
			Technical Data And Computer	1.4.2														
			Software															
		31 00 00	SD-01 Preconstruction Submittals															
			Shoring	3.5	G													
			Dewatering Work Plan	1.3.3	G													
			Blasting	1.3.2	G													

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		31 00 00	SD-03 Product Data														
			Utilization of Excavated Materials	3.9	G												
			Rock Excavation	1.3.1.2													
			Opening of any Excavation or	3.4													
			Borrow Pit														
			Shoulder Construction	3.15													
			Structural Backfill	2.7													
			SD-06 Test Reports														
			Testing	3.18													
			Borrow Site Testing	2.1													
			SD-07 Certificates														
			Testing	3.18													
		31 11 00	SD-03 Product Data														
			Nonsaleable Materials	3.6.2													
			SD-04 Samples														
			Tree wound paint	2.1													
			Herbicide	2.2													
		31 36 00	SD-04 Samples														
			Gabions	1.5.1													
			Alternative Wire Fasteners	2.1.3													
			SD-06 Test Reports														
			Gabions	1.5.1													
			Alternative Wire Fasteners	2.1.3	G												
			SD-07 Certificates														
			Stone Fill	2.1.5													
			Filter Material	2.1.6													

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		32 01 11.51	SD-04 Samples															
			Rubberandpaint removal	1.9.1														
			SD-07 Certificates															
			Schedule of work	1.7.1														
			High-pressure rubber and paint	1.8.1														
			removal equipment															
		32 01 17.16	SD-03 Product Data															
			Installation of Sealant	3.3														
			SD-04 Samples															
			Materials	1.4	G													
			SD-06 Test Reports															
			Test Requirements	1.4														
		32 01 19.61	SD-03 Product Data															
			Joint sealant	2.1.1														
			SD-04 Samples															
			Joint filler	3.1.1														
			Separating tape	2.1.3.2														
			backer rod	2.1.3.1														
			Joint sealant	2.1.1														
			SD-06 Test Reports															
			Joint sealant	2.1.1														
			SD-07 Certificates															
			Equipment list	1.6														
			SD-08 Manufacturer’s Instructions															
			Joint sealant	2.1.1														
		32 01 19	SD-03 Product Data															

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		32 01 19	Manufacturer's	1.2.2.3	G													
			Recommendations															
			Equipment	1.2														
			SD-06 Test Reports															
			Certified copies of the test reports	1.4.2	G													
		32 01 26.71	SD-03 Product Data															
			Equipment	1.1.2														
			Equipment	3.2.2														
			Procedures	3.2.1														
		32 01 29.61	SD-03 Product Data															
			Mix Design	2.1.4.1	G													
			Proprietary Cementitious	2.1.10														
			Products															
			pigmented liquid	2.1.5.2														
			membrane-forming compound															
			pigmented liquid	2.1.5.2														
			membrane-forming compound															
			SD-04 Samples															
			Absorbent curing material	3.6.3														
			Joint filler	2.1.8	G													
			Joint sealant	2.1.7	G													
			SD-05 Design Data															
			Concrete Mix Design	1.3.1	G													
			SD-06 Test Reports															
			Test Results	1.3.1	G													
			gradation	1.3.1.2														

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		32 01 29.61	gradation	2.1.1.4														
			Cement	1.3.1.1														
			slump	2.1.4.1														
			air content	2.1.4.1														
			strength	3.4.2														
			mixer calibration and efficiency	1.3.2														
			SD-07 Certificates															
			Cement	1.3.1.1	G													
			Aggregate	1.3.1.2	G													
			Admixtures	2.1.3	G													
			Absorbent curing material	3.6.3														
			pigmented liquid	2.1.5.2														
			membrane-forming compound															
			pigmented liquid	2.1.5.2														
			membrane-forming compound															
			Waterproof Sheet	2.1.5.3	G													
			Joint filler	2.1.8	G													
			Joint sealant	2.1.7	G													
		32 05 33	SD-01 Preconstruction Submittals															
			Integrated Pest Management	2.4	G													
			Plan															
			SD-03 Product Data															
			Fertilizer	2.1														
			Mulches Topdressing	2.3														
			Organic Mulch Materials	2.3.2														
			SD-07 Certificates															

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		32 05 33	Maintenance inspection report	3.5.1														
			Plant quantities	3.5.2	G													
			SD-11 Closeout Submittals															
			Tree, staking and guying removal	3.5.3														
		32 11 10	SD-06 Test Reports															
			Sampling and Testing	1.4.1														
			Approval of Materials	1.4.6	G													
			Evaluation	3.2.7														
		32 11 16.16	SD-05 Design Data															
			Gradation curve	2.1														
			SD-06 Test Reports															
			Bearing ratio	2.1														
			Liquid limit	2.1														
			Plasticity index	2.1														
			Dry weight	2.1														
			Percentage of wear	2.1														
			Gradation tests	3.4.2.1														
			Density tests	3.4.2.3														
			Materials	2.1														
			Geotextile	2.2.1														
			SD-07 Certificates															
			Source	2.2														
		32 11 16	SD-03 Product Data															
			Equipment	1.3														
			SD-06 Test Reports															
			Initial Tests	1.5.3.1														

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		32 11 16	In-Place Tests	1.5.3.2														
			SMOOTHNESS TEST	3.10														
		32 11 23	SD-03 Product Data															
			Plant, Equipment, and Tools	1.3														
			SD-06 Test Reports															
			Initial Tests	1.5.3.1														
			In-Place Tests	1.5.3.2														
			SMOOTHNESS TEST	3.6														
		32 11 24	SD-06 Test Reports															
			Gradation	3.8.2.1														
			Gradation	3.8.2.1														
			Bearing ratio	2.1.1														
			Liquid limit	2.1.1														
			Plasticity index	2.1.1														
			Percentage of wear	2.1.1														
			Dry weight	2.1.1														
			Density	3.8.2.3														
			Density	3.8.2.3														
			Smoothness	3.8.2.2														
			Thickness	3.8.2.5														
			Aggregates	2.1.1														
		32 12 10	SD-06 Test Reports															
			Sampling and Testing	3.7														
		32 12 11	SD-03 Product Data															
			Cutback Asphalt	2.1.2.1														
			Asphalt Cement	2.1.2.3														

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		32 12 11	SD-06 Test Reports															
			Aggregate Gradation Tests	1.4.2														
			Wear Test	1.4.3														
			Soundness Test	1.4.4														
			Stripping Test	1.4.5														
		32 12 15.13	SD-02 Shop Drawings															
			Placement Plan	1.2														
			SD-03 Product Data															
			Mix Design	2.3	G													
			Contractor Quality Control	3.1	G													
			SD-04 Samples															
			Asphalt Cement Binder	2.2														
			Aggregates	2.1														
			SD-06 Test Reports															
			Aggregates	2.1	G													
			QC Monitoring	3.1.3.10														
			SD-07 Certificates															
			Asphalt Cement Binder	2.2	G													
			Testing Laboratory	3.7														
		32 12 16	SD-01 Preconstruction Submittals															
			Contractor Quality Control	3.10	G													
			SD-03 Product Data															
			Mix Design	2.3	G													
			Job Mix Formula	2.3.1														
			SD-06 Test Reports															
			Aggregates	2.1	G													

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		32 12 16	Material Acceptance	3.11	G													
			Asphalt Content	3.10.3.1														
			Gradation	3.10.3.2														
			Temperatures	3.10.3.3														
			Aggregate Moisture	3.10.3.4														
			Moisture Content of Mixture	3.10.3.5														
			Laboratory Air Voids, Marshall	3.10.3.6														
			Stability and Flow															
			In-Place Density	3.10.3.7														
			Grade and Smoothness	3.10.3.8														
			SD-07 Certificates															
			Asphalt Cement Binder	2.2														
			Testing Laboratory	3.6														
		32 12 37	SD-03 Product Data															
			Sealer Mixture	2.5														
			SD-06 Test Reports															
			Sealer Materials	1.4.2	G													
		32 13 11	SD-03 Product Data															
			Equipment	2.10														
			Proposed Techniques	3.1.2	G													
			Dowels	2.8.1	G													
			Dowel Bar Assemblies	2.8.2	G													
			SD-05 Design Data															
			Proportioning Studies	2.12.2	G	ED												
			SD-06 Test Reports															
			Sampling and Testing	1.2.4	G	ED												

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		32 13 11	SD-07 Certificates														
			Contractor Quality Control Staff	1.4.1	G ED												
			Laboratory Accreditation	1.4.3	G ED												
			NRMCA Certificate of	2.10													
			Conformance														
			Commercial Laboratory	1.4.3	G ED												
		32 13 13.06	SD-03 Product Data														
			Curing materials	2.1.5													
			Admixtures	2.1.3													
			Dowel	2.1.4.1													
			Reinforcement	2.1.4.4	G												
			SD-05 Design Data														
			mix design	2.3	G												
			SD-06 Test Reports														
			Aggregate	2.1.2													
			Concrete slump tests	3.7.2													
			Air content tests	3.7.4													
			Flexural strength tests	3.7.3													
			Cementitious materials	2.1.1	G												
			SD-07 Certificates														
			Ready-mixed concrete plant	1.5.1													
			Batch tickets	1.5.4													
			Cementitious materials	2.1.1	G												
		32 13 73	SD-03 Product Data														
			Equipment	1.2													
			Manufacturer's Instructions	3.1.1													

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		32 13 73	Compression Seals	2.1													
			LUBRICANT/ADHESIVE	2.2													
			SD-06 Test Reports														
			Test Requirements	1.2.3													
		32 15 00	SD-03 Product Data														
			Equipment	1.3.4													
			SD-06 Test Reports														
			Sampling and Testing	1.3													
			Density Tests	3.12													
		32 16 13	SD-03 Product Data														
			Concrete	2.1													
			SD-06 Test Reports														
			Field Quality Control	3.8													
		32 17 24.00 10	SD-03 Product Data														
			Equipment	1.2	G												
			PAINT	2.1													
			THERMOPLASTIC	2.2													
			COMPOUNDS														
			Asphalt Concrete Primer	2.2.3													
			REFLECTIVE MEDIA	2.5													
			SD-06 Test Reports														
			Sampling and Testing	2.6													
			SD-07 Certificates														
			Qualifications	1.4.1													
			Volatile Organic Compound	2.2.3													
			(VOC)														

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		32 18 16.13	SD-02 Shop Drawings															
			Shop Drawings	1.5.4														
			Finished Grade and Underground	3.1.1														
			Utilities															
			SD-03 Product Data															
			Synthetic Surfacing	2.2														
			Loose Fill Surfacing	2.3														
			Loose Fill Surfacing system	3.3														
			Geotextile Fabric	2.4														
			Manufacturer's Qualification	1.5.1														
			Wood	2.6.2														
			Site Preparation	3.1														
			Temperature Limitation	3.2.1														
			Wood By-Products	2.3.3														
			Wood Treatment	2.6.2.2														
			Adhesive	2.2.9														
			Color	2.2.5														
			SD-06 Test Reports															
			Percolation Test	3.1.4														
			Recycled Plastic	2.5														
			Synthetic Surfacing	2.2														
			Sand	2.3.1														
			Gravel	2.3.2														
			SD-07 Certificates															
			Materials	2.1														
			Manufacturer's Qualification	1.5.1														

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		32 18 16.13	Manufacturer's Representative	1.5.2														
			Installer's Qualification	1.5.3														
			Substitution	3.1.5														
			Protective Surfacing Acceptance	3.5														
			SD-10 Operation and Maintenance															
			Data															
			Maintenance Instructions	1.8														
		32 31 13.53	SD-02 Shop Drawings															
			Fence Installation	1.3.2														
			Fence Installation	3.1														
			Installation Drawings	1.3.2														
			Location of gate, corner, end, and	1.3.2														
			pull posts															
			Gate Assembly	1.3.2														
			Gate Assembly	2.7.1														
			Gate Assembly	2.7.1														
			Turnstiles	1.3.2														
			Turnstiles	2.8														
			Gate Hardware and Accessories	1.3.2														
			Gate Hardware and Accessories	2.7.3														
			SD-03 Product Data															
			Fence Installation	1.3.2														
			Fence Installation	3.1														
			Gate Assembly	1.3.2														
			Gate Assembly	2.7.1														
			Gate Assembly	2.7.1														

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		32 31 13.53	Gate Hardware and Accessories	1.3.2														
			Gate Hardware and Accessories	1.3.2														
			Gate Hardware and Accessories	2.7.3														
			Gate Hardware and Accessories	2.7.3														
			Concrete	2.6														
			FENCE FABRIC	2.1														
			Posts	2.2														
			Post Caps	2.2.2														
			Braces	2.3														
			Line Posts	2.3														
			Sleeves	3.1.3														
			Tension Wire	2.2.2														
			Barbed Wire	2.4.2														
			Barbed Wire Supporting Arms	2.2.2														
			Barbed Tape	2.5														
			Stretcher Bars	2.1.1														
			Gate Posts	2.1.1														
			Turnstiles	1.3.2														
			Turnstiles	2.8														
			Padlocks	2.9														
			Wire Ties	2.4.1														
			ELECTRO-MECHANICAL LOCKS	2.11														
			GATE OPERATOR	2.10														
			SD-07 Certificates															
			Reports	1.3.1														

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		32 31 13.53	SD-08 Manufacturer’s Instructions															
			Fence Installation	1.3.2														
			Fence Installation	3.1														
			Gate Assembly	1.3.2														
			Gate Assembly	2.7.1														
			Gate Assembly	2.7.1														
			Hardware Assembly	3.7														
			SD-10 Operation and Maintenance															
			Data															
			Operating and maintenance	3.7														
			instructions															
		32 31 13	SD-02 Shop Drawings															
			Fence Assembly	1.3	G													
			Location of Gate, Corner, End,	3.17.1	G													
			and Pull Posts															
			Gate Assembly	1.3	G													
			Gate Hardware and Accessories	2.17	G													
			Erection/Installation Drawings	1.3	G													
			SD-03 Product Data															
			Fence Assembly	1.3														
			Gate Assembly	1.3														
			Gate Hardware and Accessories	2.17														
			Zinc Coating	2.2														
			PVC Coating	1.5.1														
			Aluminum Alloy Coating	1.5.1														
			Fabric	2.3														

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		32 31 13	Stretcher Bars	2.12														
			Concrete	2.20														
			GATE POSTS	2.15														
			SD-07 Certificates															
			Certificates of Compliance	1.5.2	G													
			SD-08 Manufacturer's Instructions															
			Fence Assembly	1.3														
			Gate Assembly	1.3														
			Hardware Assembly	1.3														
			Accessories	1.3														
		32 84 23	SD-02 Shop Drawings															
			Sprinkler System	3.2														
			SD-03 Product Data															
			Framed Instructions	3.3														
			Field Training	3.4														
			Sprinkler System	3.2														
			Spare Parts	1.5														
			Design Analysis and Calculations	1.2														
			SD-06 Test Reports															
			Field Tests	3.5														
			SD-07 Certificates															
			Sprinkler System	3.2														
			SD-10 Operation and Maintenance															
			Data															
			Sprinkler System	3.2														
		32 84 24	SD-02 Shop Drawings															

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ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION / GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	CONTRACTOR: SCHEDULE DATES APPROVAL NEEDED BY	CONTRACTOR: SCHEDULE DATES MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	CONTRACTOR ACTION DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	APPROVING AUTHORITY DATE RCD FROM OTH REVIEWER	APPROVING AUTHORITY ACTION CODE	APPROVING AUTHORITY DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		32 84 24	Irrigation sprinkler system	1.3													
			SD-03 Product Data														
			Piping materials	2.1													
			Valves	2.3													
			heads	2.2													
			Backflow preventers	2.3.6													
			Automatic controller	2.5													
			Solvent cement	2.1.4													
			Control wiring	2.6.1													
			Drip irrigation	2.1.7													
			Water hammer arresters	2.4.4.2													
			Water meter	2.4.2													
			Rain shut-off device	2.4.5.1													
			Freeze shut-off device	2.4.5.2													
			Soil moisture sensor	2.4.5.3													
			Tapping tee	2.4.1													
			Valve boxes and lids	3.1.7.3													
			Drip head accessories	2.4.3													
			SD-05 Design Data														
			System pressure calculations	1.3													
			Irrigation requirements	1.3													
			SD-06 Test Reports														
			tests	1.7.1													
			Backflow preventers	2.3.6													
			Pressure test	3.2.1													
			Operation test	3.2.2													

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		32 84 24	SD-07 Certificates															
			Backflow preventers	2.3.6														
			SD-08 Manufacturer’s Instructions															
			Automatic controller	2.5														
			heads	2.2														
			Piping materials	2.1														
			Backflow preventers	2.3.6														
			Valves	2.3														
			Solvent cement	2.1.4														
			Control wiring	2.6.1														
			Drip irrigation	2.1.7														
			Water hammer arresters	2.4.4.2														
			Water meter	2.4.2														
			Rain shut-off device	2.4.5.1														
			Freeze shut-off device	2.4.5.2														
			Soil moisture sensor	2.4.5.3														
			SD-10 Operation and Maintenance															
			Data															
			Piping materials	2.1	G													
			heads	2.2	G													
			Backflow preventers	2.3.6	G													
			Valves	2.3	G													
			Automatic controller	2.5	G													
			Drip irrigation	2.1.7	G													
			Water hammer arresters	2.4.4.2	G													
			Water meter	2.4.2	G													

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		32 84 24	Rain shut-off device	2.4.5.1	G												
			Freeze shut-off device	2.4.5.2	G												
			Soil moisture sensor	2.4.5.3	G												
			SD-11 Closeout Submittals														
			Controller Charts	3.2.3													
		32 92 19	SD-03 Product Data														
			Wood cellulose fiber mulch	2.5.3													
			Seed	2.1													
			Fertilizer	2.4													
			SD-06 Test Reports														
			Topsoil composition tests	2.2.3													
			SD-08 Manufacturer’s Instructions														
			Erosion Control Materials	2.7													
		32 92 23	SD-03 Product Data														
			Fertilizer	2.4													
			SD-06 Test Reports														
			Topsoil composition tests	2.2.3													
			SD-07 Certificates														
			sods	2.1													
		32 93 00	SD-01 Preconstruction Submittals														
			Landscape Contractor's License	1.4.3													
			Time Restrictions and Planting Conditions	1.6													
			SD-03 Product Data														
			Weed control fabric	2.6	G												
			Metal anchors	2.8.7													

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		32 93 00	Erosion control materials	2.10														
			Photographs	1.4.4	G													
			Mulch	2.7														
			SD-06 Test Reports															
			Topsoil composition tests	1.4.1														
			Topsoil composition tests	2.2.4														
			Percolation Test	1.4.5														
			SD-07 Certificates															
			Nursery certifications	1.4.2														
			Nursery certifications	2.1.1														
		32 96 00	SD-01 Preconstruction Submittals															
			Photographs	1.4.1														
			SD-02 Shop Drawings															
			Transplanting Plan	1.4.2														
			SD-03 Product Data															
			Equipment	1.4.2														
			SD-06 Test Reports															
			Soil Test	1.4.3														
			Percolation Test	1.4.4														
		33 08 55	SD-01 Preconstruction Submittals															
			Commissioning Plan	1.6	G													
			SD-06 Test Reports															
			Piping Flushing Checklist	3.5.3														
			Piping Cleaning Checklist	3.7.4														
			Control Valve Checklist	3.8.1														
			Commissioning Report	1.8														

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		33 08 55	SD-07 Certificates															
			Certification of Completion	1.7														
			Disposal of Waste Materials	1.9														
		33 11 00	SD-03 Product Data															
			Piping Materials	2.1.1														
			Water distribution main	2.1														
			Water service line	2.2														
			Hydrants	2.1.2.7	G													
			Indicator posts	2.1.2.8	G													
			Corporation stops	2.2.2.1														
			Valve boxes	2.1.2.9														
			Valve boxes	2.2.2.12														
			SD-05 Design Data															
			Design calculations of water	1.2.1														
			piping															
			SD-06 Test Reports															
			Disinfection	2.2.2.18	G													
			SD-07 Certificates															
			Water distribution main	2.1														
			Water service line	2.2														
			lining and coating	2.1.1.5														
			Lining	2.1.1.1														
			Lining	2.1.1.2														
			hydrants	2.1.2.7														
			Displacement Type Meters	2.2.2.14														
			Compound Type Meters	2.2.2.15														

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		33 11 00	SD-08 Manufacturer's Instructions															
			Delivery, storage, and handling	1.4														
			Installation	3.1.1														
		33 30 00	SD-01 Preconstruction Submittals															
			Existing Conditions	1.6														
			SD-02 Shop Drawings															
			Installation Drawings	1.4.1														
			Precast concrete manhole	2.3.1														
			Metal items	2.3.4														
			Frames, covers, and gratings	2.3.4.1														
			SD-03 Product Data															
			Pipeline materials	2.1														
			SD-06 Test Reports															
			Reports	2.4														
			SD-07 Certificates															
			Portland Cement	2.2.2														
			Gaskets	2.1.3.2														
			SD-11 Closeout Submittals															
			As-Built Drawings	1.4.1														
		33 34 00	SD-06 Test Reports															
			Hydrostatic Tests	3.2														
		33 40 00	SD-03 Product Data															
			Placing Pipe	3.3														
			SD-04 Samples															
			Pipe for Culverts and Storm	2.1														
			Drains															

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		33 40 00	SD-07 Certificates															
			Resin Certification	2.1.7														
			Resin Certification	2.1.8														
			Pipeline Testing	3.8														
			Hydrostatic Test on Watertight	2.7														
			Joints															
			Determination of Density	3.7.5														
			Frame and Cover for Gratings	2.3.7														
		33 46 16	SD-03 Product Data															
			Installation Plan	2.5.5														
			Installation Plan	2.5.5.1														
			SD-04 Samples															
			Filter Fabric	2.2														
			Pipe for Subdrains	2.1														
			SD-06 Test Reports															
			Product Certification	2.5.5														
			SD-07 Certificates															
			Filter Fabric	2.2														
			Pipe for Subdrains	2.1														
		33 51 15	SD-02 Shop Drawings															
			Pipe, Fittings, and Associated	2.1														
			Materials															
			SD-03 Product Data															
			Materials and Equipment	2.1														
			Spare Parts	1.6														
			Pipe and Accessory Coatings	2.1														

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		33 51 15	SD-05 Design Data															
			Connections to Existing Lines	1.4.2.2														
			Connections to Existing Lines	3.13														
			Connection and Abandonment	1.4.2.2	G													
			Plan															
			Connection and Abandonment	3.13.2	G													
			Plan															
			Jointing of Polyethylene and	1.4.1.2														
			Fiberglass Piping															
			SD-06 Test Reports															
			Pressure and Leak Tests	3.15.2	G													
			SD-07 Certificates															
			Welder's training, qualifications	1.4.1.1														
			and procedures															
			Utility Work	3.13.1														
			SD-10 Operation and Maintenance															
			Data															
			Gas distribution system and	1.2.1														
			equipment operation															
			Gas distribution system	1.2.2														
			maintenance															
			Gas distribution equipment	1.2.3														
			maintenance															
		33 56 10	SD-02 Shop Drawings															
			Grounding and Bonding	2.3.2														
			SD-03 Product Data															

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		33 56 10	Aboveground Storage Tank	2.4														
			Underground Storage Tank	2.5														
			Tank Protective Coatings	2.6														
			Automatic Level Alarm System	2.8														
			Tank Gauges	2.9														
			Manway Containment Sump	2.10														
			Tank Mounted Fuel Dispensing	2.11														
			Unit															
			Fuel Heaters	2.12														
			SD-06 Test Reports															
			Aboveground Storage Tank	3.2.1	G													
			Tightness Tests															
			Underground Storage Tank	3.2.2	G													
			Tightness Tests															
			Tank Manufacturer's Tests	3.2.3														
			Tank Fill Tests	3.4														
			SD-07 Certificates															
			Contractor Qualifications	1.4.1														
			Permitting	1.4.2.1														
			Registration	1.4.2.2														
			Licensed Personnel	1.4.2.3														
			Demonstrations	3.3														
			SD-08 Manufacturer’s Instructions															
			Aboveground Storage Tank	2.4														
			Underground Storage Tank	2.5														
			Automatic Level Alarm System	2.8														

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		33 56 10	Tank Gauges	2.9														
			Fuel Heaters	2.12														
			SD-10 Operation and Maintenance															
			Data															
			Aboveground Storage Tank	2.4														
			Underground Storage Tank	2.5														
			Automatic Level Alarm System	2.8														
			Tank Gauges	2.9														
			Fuel Heaters	2.12														
		33 58 00	SD-02 Shop Drawings															
			Leak Detection System	2.3	G													
			Electronic Monitoring/Alarm	2.4														
			Panel															
			Computational Pipeline	2.5														
			Monitoring System															
			SD-03 Product Data															
			Leak Detection System	2.3	G													
			Electronic Monitoring/Alarm	2.4														
			Panel															
			Computational Pipeline	2.5														
			Monitoring System															
			SD-06 Test Reports															
			Leak Detection System Test	3.2.1														
			SD-07 Certificates															
			Demonstrations	3.3														
			SD-08 Manufacturer’s Instructions															

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		33 58 00	Leak Detection System	2.3													
			SD-10 Operation and Maintenance														
			Data														
			Leak Detection System	2.3													
			Electronic Monitoring/Alarm	2.4													
			Panel														
			Computational Pipeline	2.5													
			Monitoring System														
		33 70 02.00 10	SD-02 Shop Drawings														
			Detail Drawings	1.4.1	G												
			As-Built Drawings	1.4.2													
			SD-03 Product Data														
			Fault Current Analysis	2.19.4	G												
			Protective Device	2.19	G												
			Coordination Study	2.19.5	G												
			Material and Equipment	2.1													
			Installation Requirements	3.2													
			SD-06 Test Reports														
			Factory Tests	2.17													
			Field Testing	3.12													
			Operating Tests	3.12.13													
			Cable Installation	3.3.1.4													
			Study Report	2.19.6													
			SD-07 Certificates														
			Material and Equipment	2.1													
			Cable Joints	3.4													

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		33 70 02.00 10	Installation Engineer	3.13.2														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.13.1														
			Manuals															
		33 71 01	SD-03 Product Data															
			Pole top switch	3.1.9														
			Recloser	2.17	G													
			Sectionalizer	2.18	G													
			Cutouts	2.13	G													
			Transformer	2.15	G													
			Metering equipment	2.19	G													
			Meters	2.19.3	G													
			Surge arresters	2.12														
			Steel Poles	2.2.1														
			Anchors	2.10														
			SD-06 Test Reports															
			Field Quality Control	3.6														
			Ground resistance test reports	1.5.3														
			SD-09 Manufacturer's Field															
			Reports															
			routine and other tests	2.25.2														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	1.6.1														
			Manuals															

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		33 71 01	SD-11 Closeout Submittals															
			Transformer test schedule	2.25.1														
		33 82 00	SD-02 Shop Drawings															
			Telecommunications Outside	1.6.1.1	G													
			Plant															
			Telecommunications Entrance	1.6.1.2	G													
			Facility Drawings															
			SD-03 Product Data															
			Cable splices, and connectors	2.5														
			Closures	2.3														
			Building protector assemblies	2.2.1	G													
			Protector modules	2.2.2														
			Cross-connect terminal cabinets	2.4	G													
			Spare Parts	1.8.2														
			SD-06 Test Reports															
			Pre-installation tests	3.5.1														
			Acceptance tests	3.5.2														
			SD-07 Certificates															
			Telecommunications Contractor	1.6.2.1	G													
			Key Personnel	1.6.2.2	G													
			SD-08 Manufacturer's Instructions															
			Building protector assembly	2.2.1														
			installation															
			Fiber Optic Splices	3.1.10.2														
			SD-09 Manufacturer's Field															
			Reports															

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
2014-OMA-SPECIFICATIONS_REVISION1_2015

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION: ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY: DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)		(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		33 82 00	Factory Reel Test Data	2.16.1														
			SD-11 Closeout Submittals															
			Record Documentation	1.8.1														
		34 71 13.19	SD-02 Shop Drawings															
			Installation	3.1	G													
			Equipment	3.1	G													
			Electrical Work	2.8	G													
			SD-03 Product Data															
			Barrier Systems	1.2														
			Spare Parts	1.5														
			SD-06 Test Reports															
			Field Testing	3.7														
			SD-10 Operation and Maintenance															
			Data															
			Barrier Systems	1.2	G													
			Operating and Maintenance	3.6														
			Instructions															
		34 71 13.26 31	SD-07 Certificates															
			Metal Beam Guardrail	3.1	G													
		34 73 13	SD-02 Shop Drawings															
			As-Built Drawings	1.3	G													
			SD-06 Test Reports															
			Concrete	2.6	G													
			Tests	3.5														
			SD-07 Certificates															
			Mooring Devices	2.2														

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
2014-OMA-SPECIFICATIONS_REVISION1_2015

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	CONTRACTOR ACTION ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)		(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		34 73 13	Grounding Rods	2.3														
			Grounding Connectors	2.5														
			Copper Conductors	2.4														
			Reinforcing Steel	2.7														
		40 05 13.96	SD-03 Product Data															
			Welding Operations	3.1														
			SD-06 Test Reports															
			Nondestructive Test Report	3.1														
			SD-07 Certificates															
			Qualifications	1.5														
			Welding Procedures Qualification	1.5.1														
			Certification	1.5.2.1														

SECTION 01 33 29

LEED(TM) DOCUMENTATION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

FOREST STEWARDSHIP COUNCIL (FSC)

FSC STD 01 001	(2000) Principles and Criteria for Forest Stewardship

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED	Leadership in Energy and Environmental Design(tm) Green Building Rating System for New Construction (LEED-NC)
LEED GBDC	LEED Reference Guide for Green Building Design and Construction
LEED NC	Leadership in Energy and Environmental Design(tm) New Construction Rating System

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

ANSI/SMACNA 008-2008	(2007) SMACNA IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, Chapter 3

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1113	(2004) SCAQMD Rule 1113, Architectural Coatings
SCAQMD Rule 1168	(2005) SCAQMD Amendment to South Coast Rule 1168, VOC limits

GREEN SEAL (GS)

GC-03	(1997) Green Seal Standard for Anti-Corrosive Paints
GS-11	(2010; R 2013) Green Seal Standard for Paints and Coatings
GS-36	(2011; R 2013) Green Seal Standard for Commercial Adhesives

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

LEED Implementation Plan; G

SD-07 Certificates

LEED LEED NC Accredited Professional (Building Design & Construction Specialty); G

SD-11 Closeout Submittals

LEED Documentation Notebook; G

1.3 DESCRIPTION

This project has been designed for, and shall be developed for a sustainable rating of silver in accordance with LEED NC. Table 1 (see paragraph Table) identifies the LEED NC credit items that are designed into or otherwise required for this project. No variations or substitutions to the LEED NC credits identified for this contract shall be allowed without written consent from the Contracting Officer. Should there be a case where there is any problem meeting the full requirements of a LEED NC credit identified for this project in Table 1, the Contractor must bring this to the attention of the Contracting Officer immediately.

1.3.1 Credit Validation

This project will be registered with USGBC for validation of credits earned. Contractor is not responsible for registering the project with USGBC or for paying project registration fees to USGBC. Format and content of all construction documentation must be in accordance with the LEED GBDC requirements for supporting data required in event of USGBC audit of the particular credit. Contractor is required to coordinate through the Contracting Officer with Government's LEED NC consultant on assuring assembled data is acceptable to USGBC and responding to USGBC requests for additional construction data in the course of seeking project certification.

1.3.2 Contractor Responsibilities

Some LEED NC credits are inherent in the design provided and require no further submittal or documentation. For these credits, the Contractor notify the Contracting Officer in advance of selection of any specified material or use of any permissible construction methods that may result in a deviation from the LEED designer intent. Some LEED NC credits involve material selection and are generally identified within the technical sections with the notation "LEED NC," though not specifically identified in all occurrences. Some LEED NC credits are dependent on construction practices.

All LEED credits identified in Table 1 not inherent in the design provided shall be documented by the Contractor. Table 1 provides a general summary of applicable credits. The credit templates shall be uploaded into LEED Online and updated at least monthly by Contractor. Detailed submittal requirements are contained in the LEED GBDC and in the technical sections.

In all cases where a material, product, or execution requirement is identified by "LEED NC" in the contract documents, additional data or certificates shall be submitted with the individual component or process validating the material or component to the respective LEED NC credit item. These additional data or certificates shall be separable from the other submitted data and a copy shall be included in the LEED NC Documentation Notebook in addition to the distribution indicated in the submittal register.

1.4 LEED IMPLEMENTATION PLAN

LEED NC Implementation Plan shall be submitted within 30 days after notice to proceed. The plan, when completed, shall provide a detailed description of all activities that relate to accomplishing project LEED NC requirements, including construction practices, procurement practices, and proposed submittals and documentation for each LEED NC credit. Plan shall also include the following:

a. Name of individual(s) on the Contractor's staff responsible for ensuring LEED NC credits and prerequisites are earned and responsible for assembling documentation. A responsible LEED LEED NCAccredited Professional (Building Design & Construction Specialty) shall be identified. The name and documentation of certification of the proposed LEED Accredited Professionals, no later than 14 days after the Notice to Proceed or prior to the submittal of the LEED Implementation plan. The LEED AP shall have experience as a project administer in at least one other building project of similar managerial and technical complexity that was certified by USGBC as LEED Silver or above.

b. Copy of proposed contract with Commissioning Agent.

c. Templates to be used for tracking LEED NC credits. Listing of documents to be provided for each credit and schedule for their inclusion in LEED Documentation Notebook.

d. List of all plans required in the technical sections for LEED NC credit. Proposed submittal date for each plan. These shall be added to the LEED NC Implementation Plan as they are completed.

e. Implementation plan for cumulative materials credits, which shall use applicable template with proposed materials, associated estimated costs, and details necessary for LEED NC Calculations added in order to determine if the listed materials can be expected to achieve the project goal. Submit cumulative materials implementation plans before materials purchasing begins.

The final LEED Implementation plan shall be reviewed and signed by the LEED Accredited Professional.

1.5 LEED DOCUMENTATION NOTEBOOK

The LEED Accredited Professional shall prepare a comprehensive notebook documenting compliance for each LEED NC credit identified in Table 1. LEED NC Documentation Notebook shall be formatted to match LEED NC numbering system and tabbed for each credit and prerequisite. LEED NC documentation in notebook shall contain up to date information through the previous month's work, and at least one set shall be available on the jobsite at all times. The Notebook may be maintained and available for reference electronically if preferred. Completed pages shall be prevented from being altered. If the Contractor fails to maintain the LEED NC Documentation Notebook as specified herein, the Contracting Officer will deduct from the monthly progress payment an amount representing the estimated cost of maintaining the Notebook. This monthly deduction will continue until an agreement can be reached between the Contracting Officer and the Contractor regarding the accuracy and completeness of the Notebook. The Notebook shall be reviewed and signed by the LEED Accredited Professional. The original, one copy, and an electronic version on CD of the notebook shall be submitted at project closeout.

1.5.1 Content

Notebook shall include Table 1, applicable product data for material selection, final calculations, certifications for construction practices, procurement data, cumulative calculations and other items as identified in the approved LEED NC Implementation Plan. Notebook must contain all required data to support full compliance with the indicated LEED NC credit. LEED NC credits that are inherent to the design will be documented by the designer of record.

1.5.2 LEED Calculations

Calculations showing compliance with a required LEED NC credit identified in Table 1 or within the LEED NC Implementation Plan. Calculations shall be current and available for monthly review. Final calculations shall be included in the LEED NC Documentation Notebook under the appropriate tab.

1.5.3 Submittals

All "G" designated submittals required for inclusion in the LEED Documentation Notebook shall be separable from other submitted data and shall be included in the LEED NC Documentation Notebook in addition to the distribution indicated on the submittal register.

1.6 REQUIREMENTS

LEED NC credits as identified in Table 1 shall be incorporated and documented as required by the Contract documents and in full compliance with the LEED GBDC. LEED NC credits not identified elsewhere in the Contract documents and those requiring further instruction are specified below. Refer to the LEED GBDC for further definitions and requirements.

1.6.1 Sustainable Sites, Prerequisite, Construction Activity Pollution Prevention

Develop and implement an Erosion and Sedimentation Control (ESC) Plan for all construction activities associated with the project in accordance with LEED NC. See Section 01 57 20.00 10 ENVIRONMENTAL PROTECTION and other relevant project specifications for additional requirements.

1.6.2 Energy and Atmosphere, Prerequisite, Fundamental Commissioning of the Building Energy Systems

Individual component commissioning requirements are specified in the Technical Specifications where required. Group all reports and results of commissioning into this requirement and perform commissioning work under a supervision of the Commissioning Authority for Fundamental Commissioning of the Building Energy Systems. Comply with the LEED NC.

1.6.3 Sustainable Sites, Credit, Heat Island Effect, Non-Roof

Provide any combination of shade(within 5 years of occupancy), paving materials with SRI of at least 29 and open grid pavement system, or place minimum of 50, or 100 percent of parking spaces under cover (any roof used to shade or cover parking must have an SRI of at least 29) in accordance with the LEED NC.

1.6.4 Materials and Resources, Credit, Construction Waste Management

Divert at least 50, 75, or 95 percent of all construction, demolition and land clearing waste from the waste stream by using alternatives including, but not limited to, recycling, salvage, re-use and source reduction (reducing packaging and reducing waste due to breakage, over-ordering and onsite contamination/damage of materials). See Section 01 74 19 CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT for additional requirements.

1.6.4.1 Calculations

LEED NC Letter Template forms shall be used for tracking and documentation. Amount of construction waste project materials shall be determined by the method described in the LEED GBDC. For this credit, performance is measured for the entire project.

1.6.5 Materials and Resources Credit, Materials Reuse

Project goal is that a minimum of 5, 10, or 15 percent (by dollar value) of materials and products for the project are salvaged, refurbished, or reused materials and products. Contractor shall track cumulative calculations for this credit. For this credit, performance is measured for the entire project .

1.6.6 Materials and Resources Credit, Recycled Content

Contractor shall select materials so that the sum of post-consumer recycled content value plus one-half of post-industrial recycled content value constitutes at least 10, 20, or 30 percent of the total materials cost for the project. EPA Comprehensive Procurement Guidelines has a supplier database. California Integrated Waste Management Board (CIWMB) Recycled Content Directory also contains product and supplier data at www.ciwmb.ca.gov/rcp.

1.6.6.1 Calculations

LEED NC Letter Template forms shall be used for tracking and documentation. Recycled content value of project materials shall be determined by the method described in the LEED GBDC. For this credit, performance is measured for the entire project.

1.6.6.2 Substitutions

In the case of conflict between this requirement and individual technical section requirements, Contractor may submit for Government approval proposed alternative products or systems that provide equivalent performance and appearance and have greater contribution to project recycled content requirements. All such proposed substitutions shall be submitted with the LEED NC Implementation Plan accompanied by product data that demonstrates equivalence.

1.6.7 Materials and Resources Credit, Regional Materials

Contractor shall select materials so that a minimum of 10, 20, 30 percent (by dollar value) of materials and products for the project are extracted, harvested, or recovered, as well as manufactured, regionally within a 800 kilometer (500 mile) radius of the project site.

1.6.7.1 Calculations

LEED NC Letter Template forms shall be used for tracking and documentation. Amount of regional project materials shall be determined by the method described in the LEED GBDC. For this credit, performance is measured for the entire project.

1.6.8 Materials and Resources Credit, Rapidly Renewable Materials

A minimum of 2.5, or 5.0 percent (by dollar value) of materials and products for the project shall be rapidly renewable. Rapidly renewable materials are made from plants with a 10-year or shorter harvest cycle. Contractor shall track cumulative calculations for this credit. For this credit, performance is measured for the entire project.

1.6.9 Materials and Resources Credit, Certified Wood

Contractor shall select materials so that a minimum of 50, or 95 percent (by dollar value) of permanently installed wood-based materials and products for the project are certified in accordance with FSC STD 01 001.

1.6.9.1 Calculations

LEED NC Letter Template forms shall be used for tracking and documentation. Amount of FSC-certified project materials shall be determined by the method described in the LEED GBDC. For this credit, performance is measured for the entire project .

1.6.10 Indoor Environmental Quality Credits, Construction Indoor Air Quality (IAQ) Management

An IAQ Management Plan shall be submitted within 30 days after notice to proceed. Revise and resubmit Plan as required by the Contracting Officer. Copies of the final Plan shall be made available to all workers on site. Include provisions in the Plan to meet the requirements specified below and to ensure safe, healthy air for construction workers and building occupants.

1.6.10.1 Requirements During Construction

If permanent installed air handlers are used during construction, use filters with a Minimum Efficiency Reporting Value (MERV) of 8 in permanently installed air handlers during construction.

a. Control Measures: The Contractor shall meet or exceed the requirements of ANSI/SMACNA 008-2008, Chapter 3, to help minimize contamination of the building from construction activities. The five requirements of this manual which must be adhered to are described below:

1. HVAC protection: Isolate return side of HVAC system from surrounding environment to prevent construction dust and debris from entering the duct work and spaces.

2. Source control: Use low emitting paints and other finishes, sealants, adhesives, and other materials as specified. When available, cleaning products shall have a low VOC content and be non-toxic to minimize building contamination. Utilize cleaning techniques that minimize dust generation. Cycle equipment off when not needed. Prohibit idling motor vehicles where emissions could be drawn into building. Designate receiving/storage areas for incoming material that minimize IAQ impacts.

3. Pathway interruption: When pollutants are generated use strategies such as 100 percent outside air ventilation or erection of physical barriers between work and non-work areas to prevent contamination.

4. Housekeeping: Clean frequently to remove construction dust and debris. Promptly clean up spills. Remove accumulated water and keep work areas dry to discourage the growth of mold and bacteria. Take extra measures when hazardous materials are involved.

5. Scheduling: Control the sequence of construction to minimize the absorption of VOCs by other building materials.

1.6.10.2 Requirements After Construction

After construction ends and prior to occupancy, plan a building flush-out and air quality test of the indoor air contaminant levels and conduct a building flush-out and/or air quality test of the indoor air contaminant levels per the plan. Flush-out procedure or air quality test shall comply with all requirements of this credits in LEED GBDC.

1.6.11 Indoor Environmental Quality Credit, Low Emitting Materials, Adhesives And Sealants

For field applications that are inside the weatherproofing system, use adhesives and sealants that comply with the following requirements as described below:

1) Adhesives, Sealants and Sealant Primers: Comply with SCAQMD Rule 1168. Volatile organic compound (VOC) limits listed in the LEED GBDC

2) Aerosol Adhesives: Comply with GS-36

1.6.12 Indoor Environmental Quality Credit, Low Emitting Materials - Paints And Coatings

The requirements of this section are in addition to the requirements of Section 09 90 00 PAINTS AND COATINGS. For field applications that are inside the weatherproofing system, use paints and coatings that comply with the following requirements as described below:

1) Architectural Paints and Coatings: must not exceed Volatile organic compound (VOC) content limits established in GS-11.

2) Anti-corrosive and anti-rust paints: must not exceed Volatile organic compound (VOC) content limit of 250 g/L established in GC-03.

3) Clear wood finishes, floor coatings, stains, primers and shellacs: must not exceed Volatile organic compound (VOC) content limits established in SCAQMD Rule 1113.

1.6.13 Indoor Environmental Quality Credit, Low Emitting Materials - Flooring Systems

All flooring systems installed in the interior of the building shall meet the testing and requirements of carpet; carpet cushion; carpet adhesive; hard surface flooring; alternative compliance path using FloorScore; concrete, wood, bamboo and cork floor finished; and setting adhesives and grout on LEED GBDC.

1.6.14 Indoor Environmental Quality Credit, Low Emitting Materials - Composite Wood And Agrifiber Products

For composite wood and agrifiber products installed inside the facilities, must not contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop applied composite wood and agrifiber assemblies must contain no added urea-formaldehyde resin.

1.6.15 Innovation in Design Credit, LEED Accredited Professional

At least one principal member of the project shall be LEED Accredited Professional (Building Design & Construction Specialty) and the documentation work regarding the credit shall be provided in accordance with LEED GBDC.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 COORDINATION MEETINGS

There will be three onsite coordination meetings. The first will be a preconstruction meeting to review the LEED NC Implementation Plan. The requirements for this meeting may be fulfilled during the coordination and mutual understanding meeting outlined in Section 01 45 00.00 10 QUALITY CONTROL. The second will be a pre-closeout meeting to review LEED NC Documentation Notebook for completeness and identify any outstanding issues relating to final score and documentation requirements. The third is a closeout meeting to review the final LEED NC Documentation Notebook.

All meetings shall be attended by Contractor's designated individual responsible for LEED NC documentation, Government representative and Installation representative. Contractor and all the representatives shall sign the LEED checklists at all above three meetings and all signed LEED checklists shall be filed by Contractor. At closeout meeting a final score for the project will be determined based on review of project performance and documentation. Contractor shall make a set of contract drawings and specifications available for review at each meeting as well as an updated LEED NC Documentation Notebook.

3.2 TABLE

LEED NC credits as identified in Table 1 below are contract requirements and shall be incorporated in full compliance with the LEED GBDC. Otherwise specified, table 1 is the LEED project checklist, which is provided by the Government.

-- End of Section --

SECTION 01 35 26

GOVERNMENTAL SAFETY REQUIREMENTS
02/12

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE A10.32	(2004) Fall Protection
ASSE/SAFE A10.34	(2001; R 2005) Protection of the Public on or Adjacent to Construction Sites
ASSE/SAFE Z359.1	(2007) Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components

ASME INTERNATIONAL (ASME)

ASME B30.22	(2010) Articulating Boom Cranes
ASME B30.3	(2009) Tower Cranes
ASME B30.5	(2011) Mobile and Locomotive Cranes
ASME B30.8	(2010) Floating Cranes and Floating Derricks

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 10	(2010) Standard for Portable Fire Extinguishers
NFPA 51B	(2009; TIA 09-1) Standard for Fire Prevention During Welding, Cutting, and Other Hot Work
NFPA 70E	(2015) Standard for Electrical Safety in the Workplace

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 20	Standards for Protection Against Radiation
29 CFR 1910	Occupational Safety and Health Standards

29 CFR 1910.146	Permit-required Confined Spaces
29 CFR 1926	Safety and Health Regulations for Construction
29 CFR 1926.1400	Cranes & Derricks in Construction
29 CFR 1926.16	Rules of Construction
29 CFR 1926.500	Fall Protection
CPL 2.100	(1995) Application of the Permit-Required Confined Spaces (PRCS) Standards, 29 CFR 1910.146

1.2 DEFINITIONS

a. High Visibility Accident. Any mishap which may generate publicity or high visibility.

b. Medical Treatment. Treatment administered by a physician or by registered professional personnel under the standing orders of a physician. Medical treatment does not include first aid treatment even through provided by a physician or registered personnel.

c. Recordable Injuries or Illnesses. Any work-related injury or illness that results in:

(1) Death, regardless of the time between the injury and death, or the length of the illness;

(2) Days away from work (any time lost after day of injury/illness onset);

(3) Restricted work;

(4) Transfer to another job;

(5) Medical treatment beyond first aid;

(6) Loss of consciousness; or

(7) A significant injury or illness diagnosed by a physician or other licensed health care professional, even if it did not result in (1) through (6) above.

d. "USACE" property and equipment specified in USACE EM 385-1-1 should be interpreted as Government property and equipment.

e. Weight Handling Equipment (WHE) Accident. A WHE accident occurs when any one or more of the eight elements in the operating envelope fails to perform correctly during operation, including operation during maintenance or testing resulting in personnel injury or death; material or equipment damage; dropped load; derailment; two-blocking; overload; or collision, including unplanned contact between the load, crane, or other objects. A dropped load, derailment, two-blocking, overload, or collision is considered an accident even though no material damage or injury occurs. A component failure (e.g., motor burnout, gear tooth failure, bearing failure) is not considered an accident solely due to material or equipment damage unless the component failure results in damage to other components (e.g., dropped boom, dropped load, roll over, etc.) Any mishap meeting the criteria described above shall be documented in both the Contractor Significant Incident Report (CSIR) submitted within five days both as provided by the Contracting Officer.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Government acceptance, as defined in EM 385-1-1, is required for submittals with a "G, A" designation.

SD-01 Preconstruction Submittals

SAFETY PLAN /ACCIDENT PREVENTION PLAN (APP); G

Activity Hazard Analysis (AHA); G

Crane Critical Lift Plan; G

Proof of qualification for Crane Operators; G

SD-06 Test Reports

Notifications and Reports

Submit reports as their incidence occurs, in accordance with the requirements of the paragraph, "Notifications and Reports."

Accident Reports

Crane Reports

Certificate of Compliance

SD-07 Certificates

Confined Space Entry Permit

Hot work permit

License Certificates

1.4 REGULATORY REQUIREMENTS

In addition to the detailed requirements included in the provisions of this contract, comply with the most recent edition of USACE EM 385-1-1, and all applicable host nation laws, ordinances, criteria, rules and regulations. Submit matters of interpretation of standards to the appropriate administrative agency for resolution before starting work. Where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements govern.

1.5 SITE QUALIFICATIONS, DUTIES AND MEETINGS

1.5.1 Personnel Qualifications

1.5.1.1 Site Safety and Health Officer (SSHO)

The SSHO must meet the requirements of EM 385-1-1 section 1 and ensure that the requirements of 29 CFR 1926.16 are met for the project. Provide a Safety oversight team that includes a minimum of one (1) person at each project site to function as the Site Safety and Health Officer (SSHO). The SSHO or an equally-qualified Designated Representative/alternate shall be at the work site at all times to implement and administer the Contractor's safety program and government-accepted Accident Prevention Plan. The SSHO's training, experience, and qualifications shall be as required by EM 385-1-1 paragraph 01.A.17, entitled SITE SAFETY AND HEALTH OFFICER (SSHO), and all associated sub-paragraphs.

A Competent Person shall be provided for all of the hazards identified in the Contractor's Safety and Health Program in accordance with the accepted Accident Prevention Plan, and shall be on-site at all times when the work that presents the hazards associated with their professional expertise is being performed. Provide the credentials of the Competent Persons(s) to the Contracting Officer for acceptance in consultation with the Safety Office.

1.5.1.2 Crane Operators

Meet the crane operators' requirements in USACE EM 385-1-1, Section 16 and Appendix I. In addition, for mobile cranes with Original Equipment Manufacturer (OEM) rated capacities of 50,000 pounds or greater, designate crane operators as qualified by a source that qualifies crane operators (i.e., union, a government agency, or an organization that tests and qualifies crane operators). Provide proof of current qualification.

1.5.2 Personnel Duties

1.5.2.1 Site Safety and Health Officer (SSHO)

The SSHO shall:

a. Conduct daily safety and health inspections and maintain a written log which includes area/operation inspected, date of inspection, identified hazards, recommended corrective actions, estimated and actual dates of corrections. Attach safety inspection logs to the Contractors' daily quality control report.

b. Conduct mishap investigations and complete required reports. Maintain the OSHA Form 300 and Daily Production reports for prime and sub-contractors.

c. Maintain applicable safety reference material on the job site.

d. Attend the pre-construction conference, pre-work meetings including preparatory inspection meeting, and periodic in-progress meetings.

e. Implement and enforce accepted APP and AHA.

f. Maintain a safety and health deficiency tracking system that monitors outstanding deficiencies until resolution. Post a list of unresolved safety and health deficiencies on the safety bulletin board.

g. Ensure sub-contractor compliance with safety and health requirements.

h. Maintain a list of hazardous chemicals on site and their material safety data sheets.

i. Failure to perform the above duties will result in dismissal of the superintendent, QC Manager, and/or SSHO, and a project work stoppage. The project work stoppage will remain in effect pending approval of a suitable replacement.

1.5.3 Meetings

1.5.3.1 Preconstruction Conference

a. Contractor representatives who have a responsibility or significant role in accident prevention on the project shall attend the preconstruction conference. This includes the project superintendent, site safety and health officer, quality control supervisor, or any other assigned safety and health professionals who participated in the development of the APP (including the Activity Hazard Analyses (AHA) and special plans, program and procedures associated with it).

b. Discuss the details of the submitted APP to include incorporated plans, programs, procedures and a listing of anticipated AHA that will be developed and implemented during the performance of the contract. This list of proposed AHA will be reviewed at the conference and an agreement will be reached between the Contractor and the Contracting Officer's representative as to which phases will require an analysis. In addition, establish a schedule for the preparation, submittal, review, and acceptance of AHA to preclude project delays.

c. Deficiencies in the submitted APP will be brought to the attention of the Contractor at the preconstruction conference, and the Contractor shall revise the plan to correct deficiencies and re-submit it for acceptance. Do not begin work until there is an accepted APP.

1.6 SAFETY PLAN /ACCIDENT PREVENTION PLAN (APP)

Use a qualified person to prepare the written site-specific APP. Prepare the APP in accordance with the format and requirements of USACE EM 385-1-1 and as supplemented herein. Cover all paragraph and subparagraph elements in USACE EM 385-1-1, Appendix A, "Minimum Basic Outline for Accident Prevention Plan". Specific requirements for some of the APP elements are described below. The APP shall be job-specific and address any unusual or unique aspects of the project or activity for which it is written. The APP shall interface with the Contractor's overall safety and health program. Include any portions of the Contractor's overall safety and health program referenced in the APP in the applicable APP element and made site-specific. The Government considers the Prime Contractor to be the "controlling authority" for all work site safety and health of the subcontractors. Contractors are responsible for informing their subcontractors of the safety provisions under the terms of the contract and the penalties for noncompliance, coordinating the work to prevent one craft from interfering with or creating hazardous working conditions for other crafts, and inspecting subcontractor operations to ensure that accident prevention responsibilities are being carried out. The APP shall be signed by the person and firm (senior person) preparing the APP, the Contractor, the on-site superintendent, the designated site safety and health officer, the Contractor Quality control Manager, and any designated CSP or CIH.

Submit the APP to the Contracting Officer 7 calendar days prior to the date of the preconstruction conference for acceptance. Work cannot proceed without an accepted APP.

Once accepted by the Contracting Officer, the APP and attachments will be enforced as part of the contract. Disregarding the provisions of this contract or the accepted APP will be cause for stopping of work, at the discretion of the Contracting Officer, until the matter has been rectified.

Once work begins, changes to the accepted APP shall be made with the knowledge and concurrence of the Contracting Officer, project superintendent, SSHO and quality control manager. Should any severe hazard exposure, i.e. imminent danger, become evident, stop work in the area, secure the area, and develop a plan to remove the exposure and control the hazard. Notify the Contracting Officer within 24 hours of discovery. Eliminate/remove the hazard. In the interim, take all necessary action to restore and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public (as defined by ASSE/SAFE A10.34,) and the environment.

Copies of the accepted plan will be maintained at the Contracting Officer's office and at the job site. Continuously review and amend the APP, as necessary, throughout the life of the contract. Incorporate unusual or high-hazard activities not identified in the original APP as they are discovered.

1.6.1 EM 385-1-1 Contents

In addition to the requirements outlined in Appendix A of USACE EM 385-1-1, the following is required:

a. Crane Critical Lift Plan. Prepare and sign weight handling critical lift plans for lifts over 75 percent of the capacity of the crane or hoist (or lifts over 50 percent of the capacity of a barge mounted mobile crane's hoists) at any radius of lift; lifts involving more than one crane or hoist; lifts of personnel; and lifts involving non-routine rigging or operation, sensitive equipment, or unusual safety risks. Submit 15 calendar days prior to on-site work and include the requirements of USACE EM 385-1-1, paragraph 16.H. and the following:

   For lifts of personnel, demonstrate compliance with the requirements of 29 CFR 1926.1400.

b. Occupant Protection Plan. The safety and health aspects of lead-based paint removal, prepared in accordance with Section 02 83 19.00 10 LEAD BASED PAINT HAZARD ABATEMENT, TARGET HOUSING & CHILD OCCUPIED FACILITIES.

c. Asbestos Hazard Abatement Plan. The safety and health aspects of asbestos work, prepared in accordance with Section 02 82 14.00 10 ASBESTOS HAZARD CONTROL ACTIVITIES.

d. Site Safety and Health Plan. The safety and health aspects prepared in accordance with Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES.

e. Site Demolition Plan. The safety and health aspects prepared in accordance with Section 02 41 00 DEMOLITION AND DECONSTRUCTION and referenced sources. Include engineering survey as applicable.

f. Excavation Plan. The safety and health aspects prepared in accordance with Section 31 00 00 EARTHWORK.

1.7 ACTIVITY HAZARD ANALYSIS (AHA)

The Activity Hazard Analysis (AHA) format shall be in accordance with USACE EM 385-1-1, Section 1. Submit the AHA for review at least 15 calendar days prior to the start of each phase. Format subsequent AHA as amendments to the APP. The analysis should be used during daily inspections to ensure the implementation and effectiveness of the activity's safety and health controls.

The AHA list will be reviewed periodically (at least monthly) at the Contractor supervisory safety meeting and updated as necessary when procedures, scheduling, or hazards change.

Develop the activity hazard analyses using the project schedule as the basis for the activities performed. Any activities listed on the project schedule will require an AHA. The AHA will be developed by the contractor, supplier or subcontractor and provided to the prime contractor for submittal to the Contracting Officer.

1.8 DISPLAY OF SAFETY INFORMATION

Within one calendar day(s) after commencement of work, erect a safety bulletin board at the job site. Where size, duration, or logistics of project do not facilitate a bulletin board, an alternative method, acceptable to the Contracting Officer, that is accessible and includes all mandatory information for employee and visitor review, shall be deemed as meeting the requirement for a bulletin board. Include and maintain information on safety bulletin board as required by EM 385-1-1, section 01.A.06. Additional items required to be posted include:

a. Confined space entry permit.

b. Hot work permit.

1.9 SITE SAFETY REFERENCE MATERIALS

Maintain safety-related references applicable to the project, including those listed in the article "References." Maintain applicable equipment manufacturer's manuals.

1.10 EMERGENCY MEDICAL TREATMENT

Contractors will arrange for their own emergency medical treatment. Government has no responsibility to provide emergency medical treatment.

1.11 NOTIFICATIONS and REPORTS

1.11.1 Accident Notification

Notify the Contracting Officer as soon as practical, but no more than four hours after any accident meeting the definition of Recordable Injuries or Illnesses or High Visibility Accidents, property damage equal to or greater than $2,000, or any weight handling equipment accident. Within notification include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (to include type of construction equipment used, PPE used, etc.). Preserve the conditions and evidence on the accident site until the Government investigation team arrives on-site and Government investigation is conducted.

1.11.2 Accident Reports

a. Conduct an accident investigation for recordable injuries and illnesses, for Medical Treatment defined in paragraph DEFINITIONS, property damage accidents resulting in at least $20,000 in damages, and near misses as defined in EM 385-1-1, to establish the root cause(s) of the accident. The Contracting Officer will provide copies of any required or special forms.

b. Conduct an accident investigation for any weight handling equipment accident (including rigging gear accidents) to establish the root cause(s) of the accident, complete the WHE Accident Report (Crane and Rigging Gear) form and provide the report to the Contracting Officer within 30 calendar days of the accident. Do not proceed with crane operations until cause is determined and corrective actions have been implemented to the satisfaction of the contracting officer. The Contracting Officer will provide a blank copy of the accident report form.

1.11.3 Crane Reports

Submit crane inspection reports required in accordance with USACE EM 385-1-1, Appendix I and as specified herein with Daily Reports of Inspections.

1.11.4 Certificate of Compliance

Provide a Certificate of Compliance for each crane entering an activity under this contract (see Contracting Officer for a blank certificate). State within the certificate that the crane and rigging gear meet applicable OSHA regulations (with the Contractor citing which OSHA regulations are applicable, e.g., cranes used in construction, demolition, or maintenance comply with 29 CFR 1926 and USACE EM 385-1-1 Section 16 and Appendix I. Certify on the Certificate of Compliance that the crane operator(s) is qualified and trained in the operation of the crane to be used. For cranes at DOD activities in foreign countries, certify that the crane and rigging gear conform to the appropriate host country safety standards. Also certify that all of its crane operators working on the DOD activity have been trained in the proper use of all safety devices (e.g., anti-two block devices). Post certifications on the crane.

1.12 HOT WORK

Submit and obtain a written permit prior to performing "Hot Work" (welding, cutting, etc.) or operating other flame-producing/spark producing devices, from the Fire Division. A permit is required from the Explosives Safety Office for work in and around where explosives are processed, stored, or handled. CONTRACTORS ARE REQUIRED TO MEET ALL CRITERIA BEFORE A PERMIT IS ISSUED. Provide at least two (2) twenty (20) pound 4A:20 BC rated extinguishers for normal "Hot Work". All extinguishers shall be current inspection tagged, approved safety pin and tamper resistant seal. It is also mandatory to have a designated FIRE WATCH for any "Hot Work" done at this activity. The Fire Watch shall be trained in accordance with NFPA 51B and remain on-site for a minimum of 30 minutes after completion of the task or as specified on the hot work permit.

When starting work in the facility, require personnel to familiarize themselves with the location of the nearest fire alarm boxes and place in memory the emergency Fire Division phone number. ANY FIRE, NO MATTER HOW SMALL, SHALL BE REPORTED TO THE RESPONSIBLE FIRE DIVISION IMMEDIATELY.

1.13 RADIATION SAFETY REQUIREMENTS

License Certificates for radiation materials and equipment shall be submitted to the Contracting Officer and Radiation Safety Office (RSO)for all specialized and licensed material and equipment that could cause fatal harm to construction personnel or to the construction project.

Workers shall be protected from radiation exposure in accordance with 10 CFR 20, Standards for Protection Against Radiation

Loss of radioactive material shall be reported immediately to the Contracting Officer.

Actual exposure of the radiographic film or unshielding of the source shall not be initiated until after 5 p.m. on weekdays.

In instances where radiography is scheduled near or adjacent to buildings or areas having limited access or one-way doors, no assumptions shall be made as to building occupancy. Where necessary, the Contracting Officer will direct the Contractor to conduct an actual building entry, search, and alert. Where removal of personnel from such a building cannot be accomplished and it is otherwise safe to proceed with the radiography, a fully instructed employee shall be positioned inside such building or area to prevent exiting while external radiographic operations are in process. Transportation of Regulated Amounts of Radioactive Material will comply with 49 CFR, Subchapter C, Hazardous Material Regulations. Local Fire authorities and the site Radiation Safety officer (RSO) shall be notified of any Radioactive Material use.

Transmitter Requirements: The base policy concerning the use of transmitters such as radios, cell phones, etc., must be adhered to by all contractor personnel. They must also obey Emissions control (EMCON) restrictions.

1.14 FACILITY OCCUPANCY CLOSURE

Streets, walks, and other facilities occupied and used by the Government shall not be closed or obstructed without written permission from the

Contracting Officer.

1.15 SEVERE STORM PLAN

In the event of a severe storm warning, the Contractor must:

a. Secure outside equipment and materials and place materials that could be damaged in protected areas.

b. Check surrounding area, including roof, for loose material, equipment, debris, and other objects that could be blown away or against existing facilities.

c. Ensure that temporary erosion controls are adequate.

1.16 CONFINED SPACE ENTRY REQUIREMENTS.

Contractors entering and working in confined spaces while performing general industry work are required to follow the requirements of OSHA 29 CFR 1926 and comply with the requirements in Section 34 of EM 385-1-1, OSHA 29 CFR 1910, and OSHA 29 CFR 1910.146.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 CONSTRUCTION AND OTHER WORK

3.1.1 Hazardous Material Exclusions

Notwithstanding any other hazardous material used in this contract, radioactive materials or instruments capable of producing ionizing/non-ionizing radiation (with the exception of radioactive material and devices used in accordance with USACE EM 385-1-1 such as nuclear density meters for compaction testing and laboratory equipment with radioactive sources) as well as materials which contain asbestos, mercury or polychlorinated biphenyls, diisocynates, lead-based paint are prohibited. The Contracting Officer, upon written request by the Contractor, may consider exceptions to the use of any of the above excluded materials. Low mercury lamps used within fluorescent lighting fixtures are allowed as an exception without further Contracting Officer approval. Notify the Radiation Safety Officer (RSO) prior to excepted items of radioactive material and devices being brought on base.

3.1.2 Unforeseen Hazardous Material

The design should have identified materials such as PCB, lead paint, and friable and non-friable asbestos and other OSHA regulated chemicals (i.e. 29 CFR Part 1910.1000). If any material, not indicated, that may be hazardous to human health upon disturbance during construction operations is encountered, stop that portion of work and notify the Contracting Officer immediately. Within 14 calendar days the Government will determine if the material is hazardous. If material is not hazardous or poses no danger, the Government will direct the Contractor to proceed without change. If material is hazardous and handling of the material is necessary to accomplish the work, the Government will issue a modification pursuant to "FAR 52.243-4, Changes" and "FAR 52.236-2, Differing Site

Conditions."

3.2 PRE-OUTAGE COORDINATION MEETING

Apply for utility outages at least 30 days in advance. As a minimum, the request should include the location of the outage, utilities being affected, duration of outage and any necessary sketches. Special requirements for electrical outage requests are contained elsewhere in this specification section. Once approved, and prior to beginning work on the utility system requiring shut down, attend a pre-outage coordination meeting with the Contracting Officer and the Installation representative to review the scope of work and the lock-out/tag-out procedures for worker protection. No work will be performed on energized electrical circuits unless proof is provided that no other means exist.

3.3 CONTROL OF HAZARDOUS ENERGY (LOCKOUT/TAGOUT)

Ensure that each employee is familiar with and complies with these procedures and USACE EM 385-1-1, Section 12, Control of Hazardous Energy.

3.4 FALL HAZARD PROTECTION AND PREVENTION PROGRAM

Establish a fall protection and prevention program, for the protection of all employees exposed to fall hazards. Within the program include company policy, identify responsibilities, education and training requirements, fall hazard identification, prevention and control measures, inspection, storage, care and maintenance of fall protection equipment and rescue and evacuation procedures.

3.4.1 Training

Institute a fall protection training program. As part of the Fall Hazard Protection and Prevention Program, provide training for each employee who might be exposed to fall hazards. Provide training by a competent person for fall protection in accordance with USACE EM 385-1-1, Section 21.B.

3.4.2 Fall Protection Equipment and Systems

Enforce use of the fall protection equipment and systems designated for each specific work activity in the Fall Protection and Prevention Plan and/or AHA at all times when an employee is exposed to a fall hazard. Protect employees from fall hazards as specified in EM 385-1-1, Section 21. In addition to the required fall protection systems, safety skiff, personal floatation devices, life rings etc., are required when working above or next to water in accordance with USACE EM 385-1-1, Paragraphs 21.N through 21.N.04. Personal fall arrest systems are required when working from an articulating or extendible boom, swing stages, or suspended platform. In addition, personal fall arrest systems are required when operating other equipment such as scissor lifts if the work platform is capable of being positioned outside the wheelbase. The need for tying-off in such equipment is to prevent ejection of the employee from the equipment during raising, lowering, or travel. Fall protection must comply with 29 CFR 1926.500, Subpart M, USACE EM 385-1-1 and ASSE/SAFE A10.32.

3.4.2.1 Personal Fall Arrest Equipment

Personal fall arrest equipment, systems, subsystems, and components shall meet ASSE/SAFE Z359.1. Only a full-body harness with a shock-absorbing lanyard or self-retracting lanyard is an acceptable personal fall arrest body support device. Body belts may only be used as a positioning device system (for uses such as steel reinforcing assembly and in addition to an approved fall arrest system). Harnesses shall have a fall arrest attachment affixed to the body support (usually a Dorsal D-ring) and specifically designated for attachment to the rest of the system. Only locking snap hooks and carabiners shall be used. Webbing, straps, and ropes shall be made of synthetic fiber. The maximum free fall distance when using fall arrest equipment shall not exceed 1.8 m (6 feet). The total fall distance and any swinging of the worker (pendulum-like motion) that can occur during a fall shall always be taken into consideration when attaching a person to a fall arrest system.

3.4.3 Fall Protection for Roofing Work

Implement fall protection controls based on the type of roof being constructed and work being performed. Evaluate the roof area to be accessed for its structural integrity including weight-bearing capabilities for the projected loading.

a. Low Sloped Roofs:

(1) For work within 1.8 m (6 feet) of an edge, on low-slope roofs, protect personnel from falling by use of personal fall arrest systems, guardrails, or safety nets.

(2) For work greater than 1.8 m (6 feet) from an edge, erect and install warning lines in accordance with 29 CFR 1926.500 and USACE EM 385-1-1.

b. Steep-Sloped Roofs: Work on steep-sloped roofs requires a personal fall arrest system, guardrails with toe-boards, or safety nets. This requirement also includes residential or housing type construction.

3.4.4 Horizontal Lifelines

Design, install, certify and use under the supervision of a qualified person horizontal lifelines for fall protection as part of a complete fall arrest system which maintains a safety factor of 2 (29 CFR 1926.500).

3.4.5 Guardrails and Safety Nets

Design, install and use guardrails and safety nets in accordance with EM 385-1-1 and 29 CFR 1926 Subpart M.

3.4.6 Rescue and Evacuation Procedures

When personal fall arrest systems are used, ensure that the mishap victim can self-rescue or can be rescued promptly should a fall occur. Prepare a Rescue and Evacuation Plan and include a detailed discussion of the following: methods of rescue; methods of self-rescue; equipment used; training requirement; specialized training for the rescuers; procedures for requesting rescue and medical assistance; and transportation routes to a medical facility. Include the Rescue and Evacuation Plan within the Activity Hazard Analysis (AHA) for the phase of work, in the Fall Protection and Prevention (FP&P) Plan, and the Accident Prevention Plan (APP).

3.5 EQUIPMENT

3.5.1 Material Handling Equipment

a. Material handling equipment such as forklifts shall not be modified with work platform attachments for supporting employees unless specifically delineated in the manufacturer's printed operating instructions.

b. The use of hooks on equipment for lifting of material must be in accordance with manufacturer's printed instructions.

c. Operators of forklifts or power industrial trucks shall be licensed in accordance with OSHA.

3.5.2 Weight Handling Equipment

a. Equip cranes and derricks as specified in EM 385-1-1, section 16.

b. Comply with the crane manufacturer's specifications and limitations for erection and operation of cranes and hoists used in support of the work. Perform erection under the supervision of a designated person (as defined in ASME B30.5). Perform all testing in accordance with the manufacturer's recommended procedures.

c. Comply with ASME B30.5 for mobile and locomotive cranes, ASME B30.22 for articulating boom cranes, ASME B30.3 for construction tower cranes, and ASME B30.8 for floating cranes and floating derricks.

d. Under no circumstance shall a Contractor make a lift at or above 90 percent of the cranes rated capacity in any configuration.

e. When operating in the vicinity of overhead transmission lines, operators and riggers shall be alert to this special hazard and follow the requirements of USACE EM 385-1-1 Section 11 and ASME B30.5 or ASME B30.22 as applicable.

f. Do not crane suspended personnel work platforms (baskets) unless the Contractor proves that using any other access to the work location would provide a greater hazard to the workers or is impossible. Do not lift personnel with a line hoist or friction crane.

g. Inspect, maintain, and recharge portable fire extinguishers as specified in NFPA 10, Standard for Portable Fire Extinguishers.

h. All employees must keep clear of loads about to be lifted and of suspended loads.

i. Use cribbing when performing lifts on outriggers.

j. The crane hook/block must be positioned directly over the load. Side loading of the crane is prohibited.

k. A physical barricade must be positioned to prevent personnel from entering the counterweight swing (tail swing) area of the crane.

l. Certification records which include the date of inspection, signature of the person performing the inspection, and the serial number or other identifier of the crane that was inspected shall always be available for review by Contracting Officer personnel.

m. Written reports listing the load test procedures used along with any repairs or alterations performed on the crane shall be available for review by Contracting Officer personnel.

n. Certify that all crane operators have been trained in proper use of all safety devices (e.g. anti-two block devices).

3.5.3 USE OF EXPLOSIVES

Explosives shall not be used or brought to the project site without prior written approval from the Contracting Officer. Such approval shall not relieve the Contractor of responsibility for injury to persons or for damage to property due to blasting operations.

Storage of explosives, when permitted on Government property, shall be only where directed and in approved storage facilities. These facilities shall be kept locked at all times except for inspection, delivery, and withdrawal of explosives.

3.6 EXCAVATIONS

Soil classification must be performed by a competent person in accordance with 29 CFR 1926 and EM 385-1-1.

3.6.1 Utility Locations

All underground utilities in the work area must be positively identified by the installation utility departments.

3.6.2 Utility Location Verification

Physically verify underground utility locations, including utility depth, by hand digging using wood or fiberglass handled tools when any adjacent construction work is expected to come within three feet of the underground system.

3.6.3 Utilities Within and Under Concrete, Bituminous Asphalt, and Other Impervious Surfaces

Utilities located within and under concrete slabs or pier structures, bridges, parking areas, and the like, are extremely difficult to identify. Whenever contract work involves chipping, saw cutting, or core drilling through concrete, bituminous asphalt or other impervious surfaces, the existing utility location must be coordinated with installation utility departments. Outages to isolate utility systems must be used in circumstances where utilities are unable to be positively identified. The use of historical drawings does not alleviate the contractor from meeting this requirement.

3.7 ELECTRICAL

3.9.1 Portable Extension Cords

Size portable extension cords in accordance with manufacturer ratings for the tool to be powered and protected from damage. Immediately removed from service all damaged extension cords. Portable extension cords shall meet the requirements of EM 385-1-1, NFPA 70E, and OSHA electrical standards.

3.8 WORK IN CONFINED SPACES

Comply with the requirements in Section 34 of USACE EM 385-1-1, OSHA 29 CFR 1910, OSHA 29 CFR 1910.146, OSHA Directive CPL 2.100 and OSHA 29 CFR 1926. Any potential for a hazard in the confined space requires a permit system to be used.

a. Entry Procedures. Prohibit entry into a confined space by personnel for any purpose, including hot work, until the qualified person has conducted appropriate tests to ensure the confined or enclosed space is safe for the work intended and that all potential hazards are controlled or eliminated and documented. (See Section 34 of USACE EM 385-1-1 for entry procedures.) All hazards pertaining to the space shall be reviewed with each employee during review of the AHA.

b. Forced air ventilation is required for all confined space entry operations and the minimum air exchange requirements must be maintained to ensure exposure to any hazardous atmosphere is kept below its' action level.

c. Sewer wet wells require continuous atmosphere monitoring with audible alarm for toxic gas detection.

-- End of Section --

SECTION 01 35 29.13

HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 1604	(1996; R 2001) Closure of Underground Petroleum Storage Tanks
API RP 2219	(2005) Safe Operation of Vacuum Trucks in Petroleum Service
API Std 2015	(2001; R 2006) Safe Entry and Cleaning of Petroleum Storage Tanks

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

ANSI/ISEA Z358.1	(2009) American National Standard for Emergency Eyewash and Shower Equipment

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 85-115	(1985) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual
ER 385-1-95	(2007; Errata 2007) Safety -- Safety and Health Requirements for Munitions and Explosives of Concern (MEC) Operations

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1904	Recording and Reporting Occupational Injuries and Illnesses
29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.120	Hazardous Waste Operations and Emergency Response
29 CFR 1926	Safety and Health Regulations for Construction

29 CFR 1926.65	Hazardous Waste Operations and Emergency Response
49 CFR 171	General Information, Regulations, and Definitions
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.2 DESCRIPTION OF WORK

This section requires Contractors to implement practices and procedures for working safely and in compliance with OSHA and USACE regulation while performing cleanup activities on uncontrolled hazardous waste sites.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Work Zones; G
Decontamination Facilities; G

SD-03 Product Data

Exposure Monitoring/Air Sampling Program
Site Control Log
Employee Certificates

1.4 REGULATORY REQUIREMENTS

Comply with EM 385-1-1, OSHA requirements in 29 CFR 1910 and 29 CFR 1926 with work performed under this contract, especially OSHA's Standards 29 CFR 1926.65 and 29 CFR 1910.120 and local specific OSHA (or ROK equivalent) requirements where applicable. Submit to the Contracting Officer for resolution matters of interpretation of standards before starting work. The most stringent requirements apply where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary.

1.5 PRECONSTRUCTION SAFETY CONFERENCE

Conduct a preconstruction safety conference prior to the start of site activities and after submission of the Contractor's APP/SSHP. The objective of the meeting will be to discuss health and safety concerns related to the impending work, discuss project health and safety organization and expectations, review and answer comments and concerns regarding the APP/SSHP or other health and safety concerns the Contractor may have. Ensure that those individuals responsible for health and safety at the project level are available and attend this meeting.

1.6 ACCIDENT PREVENTION PLAN/SITE SAFETY AND HEALTH PLAN (APP/SSHP)

Develop and implement a Site Safety and Health Plan and attach to the Accident Prevention Plan (APP) as an appendix (APP/SSHP). Address all occupational safety and health hazards (traditional construction as well as contaminant-related hazards) associated with cleanup operations within the APP/SSHP. Cover each SSHP element in section 28.A.01 of EM 385-1-1 and each APP element in Appendix A of EM 385-1-1. There are overlapping elements in Section 28.A.01 and Appendix A of EM 385-1-1. SSHP appendix elements that overlap with APP elements need not be duplicated in the APP/SSHP provided each SOH issue receives adequate attention and is documented in the APP/SSHP. The APP/SSHP is a dynamic document, subject to change as project operations/execution change. The APP/SSHP will require modification to address changing and previously unidentified health and safety conditions. It is the Contractor's responsibility to ensure that the APP/SSHP is updated accordingly. Submit amendments to the APP/SSHP to the COR as the APP/SSHP is updated. For long duration projects resubmit the APP/SSHP to the COR annually for review. The APP/SSHP must contain all updates.

1.6.1 Acceptance and Modifications

Prior to submittal, the APP/SSHP must be signed and dated by the Safety and Health Manager and the Site Superintendent. Submit for review 7 days prior to the Preconstruction Safety Conference. Deficiencies in the APP/SSHP will be discussed at the preconstruction safety conference, and be revised to correct the deficiencies and resubmitted for acceptance. Onsite work must not begin until the plan has been accepted. Maintain a copy of the written APP/SSHP onsite. Changes and modifications to must be made with the knowledge and concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Bring to the attention of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer any unforeseen hazard that becomes evident during the performance of the work, through the Site Safety and Health Officer (SSHO) for resolution as soon as possible. In the interim, take necessary action to re-establish and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public, and the environment. Disregard for the provisions of this specification or the accepted APP/SSHP will be cause for stopping work until the matter has been rectified.

1.6.2 Availability

Make available the APP/SSHP in accordance with 29 CFR 1910.120, (b)(1)(v) and 29 CFR 1926.65, (b)(1)(v).

1.7 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

1.7.1 Project/Site Conditions

Refer to the following reports and information for the site description and contamination characterization.

1.7.1.1 UST Documents

As described in the Task Order, Delivery Order, or contract documents..

1.7.2 Ordnance and Explosives (OE)

Stop work and contact the Contracting Officer (KO) if ordnance and explosives (OE), explosive media or chemical agent contaminated media (CACM) are discovered during hazardous waste site cleanup activities. Proceed with work after the KO gives permission and, according to ER 385-1-95 requirements.

1.8 TASK SPECIFIC HAZARDS, INITIAL PPE, HAZWOPER MEDICAL SURVEILLANCE AND TRAINING APPLICABILITY

Task specific occupational hazards, task specific HAZWOPER medical surveillance and training applicability and task specific initial PPE requirements for the project are listed on the Task Hazard and Control Sheets at the end of this section. It is the Contractor's responsibility to reevaluate occupational safety and health hazards as the work progresses and to adjust the PPE and onsite operations, if necessary, so that the work is performed safely and in compliance with occupational safety and health regulations.

1.9 STAFF ORGANIZATION, QUALIFICATION AND RESPONSIBILITIES

1.9.1 Safety and Health Manager

Safety and Health Manager must be an Industrial Hygienist certified by the American Board of Industrial Hygiene, or a safety professional certified by the Board of Certified Safety Professionals, or an individual with equivalent certification from the Korean government. The name, qualifications (education summary and documentation, ABIH or BCSP certificate), and work experience summary shall be included in the SSHP.

1.9.1.1 Additional Qualifications

The Safety and Health Manager must have the following additional qualifications:

a. A minimum of 3 years experience in developing and implementing safety and health programs at underground storage tank removal projects.

b. Documented experience in supervising professional and technician level personnel.

c. Documented experience in developing worker exposure assessment programs and air monitoring programs and techniques.

d. Documented experience in managing personal protective equipment programs and conducting PPE hazard evaluations for the types of activities and hazards likely to be encountered on the project.

e. Working knowledge of state and Federal occupational safety and health regulations.

1.9.1.2 Responsibilities and Duties

The Safety and Health Manager shall:

a. Be responsible for the development, implementation, oversight, and enforcement of the APP/SSHP.

b. Sign and date the APP/SSHP prior to submittal.

c. Conduct initial site-specific training.

d. Be available for consultation during the first 3 days of remedial activities and at the startup of each new major phase of work.

e. Visit the site as needed and at least once per month for the duration of activities, to audit the effectiveness of the APP/SSHP.

f. Be available for emergencies.

g. Provide onsite consultation as needed to ensure the APP/SSHP is fully implemented.

h. Coordinate any modifications to the APP/SSHP with the Site Superintendent, the SSHO, and the Contracting Officer.

i. Provide continued support for upgrading/downgrading of the level of personal protection.

j. Be responsible for evaluating air monitoring data and recommending changes to engineering controls, work practices, and PPE.

k. Review accident reports and results of daily inspections.

1.9.2 Site Safety and Health Officer

Designate an individual and one alternate as the Site Safety and Health Officer (SSHO). The name, qualifications (education and training summary and documentation), and include work experience of the Site Safety and Health Officer and alternate in the APP/SSHP.

1.9.2.1 Qualifications

The SSHO shall meet the following qualifications:

a. A minimum of 1 year experience in implementing safety and health programs at underground storage tank removal projects where Level B personal protective equipment was required.

b. Documented experience in construction techniques and construction safety procedures.

c. Working knowledge of Federal and state occupational safety and health regulations.

d. Specific training in personal and respiratory protective equipment, confined space entry and in the proper use of air monitoring instruments and air sampling methods including monitoring for ionizing radiation.

1.9.2.2 Responsibilities and Duties

The Site Safety and Health Officer shall:

a. Assist and represent the Safety and Health Manager in onsite training and the day to day onsite implementation and enforcement of the accepted APP/SSHP.

b. Be assigned to the site on a full time basis for the duration of field activities. The SSHO can have collateral duties in addition to Safety and Health related duties. If operations are performed during more than 1 work shift per day, a site Safety and Health Officer must be present for each shift and when applicable, act as the radiation safety officer (RSO) as defined in paragraph 06.E.02 of EM 385-1-1 on radioactive waste cleanup projects.

c. Have authority to ensure site compliance with specified safety and health requirements, Federal, state and OSHA regulations and all aspects of the APP/SSHP including, but not limited to, activity hazard analyses, air monitoring, monitoring for ionizing radiation, use of PPE, decontamination, site control, standard operating procedures used to minimize hazards, safe use of engineering controls, the emergency response plan, confined space entry procedures, spill containment program, and preparation of records by performing a daily safety and health inspection and documenting results on the Daily Safety Inspection Log in accordance with 29 CFR 1904.

d. Have authority to stop work if unacceptable health or safety conditions exist, and take necessary action to re-establish and maintain safe working conditions.

e. Consult with and coordinate any modifications to the APP/SSHP with the Safety and Health Manager, the Site Superintendent, and the Contracting Officer.

f. Conduct accident investigations and prepare accident reports.

g. Conduct daily safety inspection and document safety and health findings into the Daily Safety Inspection Log. Track noted safety and health deficiencies to ensure that they are corrected.

h. In coordination with site management and the Safety and Health Manager, recommend corrective actions for identified deficiencies and oversee the corrective actions.

1.9.3 Occupational Physician

Utilize the services of a licensed physician, who is certified in occupational medicine by the American Board of Preventative Medicine, or who, by necessary training and experience is Board eligible. The physician must be familiar with this site's hazards and the scope of this project. Include the medical consultant's name, qualifications, and knowledge of the site's conditions and proposed activities in the APP/SSHP. The physician will be responsible for the determination of medical surveillance protocols and for review of examination/test results performed in compliance with 29 CFR 1910.120, (f) and 29 CFR 1926.65, (f) and paragraph MEDICAL SURVEILLANCE.

1.9.4 Persons Certified in First Aid and CPR

At least two persons who are currently certified in first aid and CPR by the American Red Cross or other approved agency must be onsite at all times during site operations. They must be trained in universal precautions and the use of PPE as described in the Blood Borne Pathogens Standard of 29 CFR 1910, Section .1030. These persons may perform other duties but will be immediately available to render first aid when needed.

1.9.5 Safety and Health Technicians

For each work crew in the exclusion zone, one person, designated as a Safety and Health technician, must perform activities such as air monitoring, decontamination, and safety oversight on behalf of the SSHO. They must have appropriate training equivalent to the SSHO in each specific area for which they have responsibility and report to and be under the supervision of the SSHO.

1.10 TRAINING

Meet the following requirements in the Contractor's training program for workers performing cleanup operations and who will be exposed to contaminants.

1.10.1 General Hazardous Waste Operations Training

All Personnel performing duties with potential for exposure to onsite contaminants must meet and maintain the following 29 CFR 1910.120/ 29 CFR 1926.65 (e) training requirements:

a. 40 hours of offsite hazardous waste instruction.

b. 3 days actual field experience under the direct supervision of a trained, experienced supervisor.

c. 8 hours refresher training annually.

Onsite supervisors must have an additional 8 hours management and supervisor training specified in 29 CFR 1910.120/29 CFR 1926.65 (e) (4).

1.10.2 Pre-entry Briefing

Prior to commencement of onsite field activities, all site employees, including those assigned only to the Support Zone, must attend a site-specific safety and health training session. This session will be conducted by the Safety and Health Manager and the Site Safety and Health Officer to ensure that all personnel are familiar with requirements and responsibilities for maintaining a safe and healthful work environment. Thoroughly discuss procedures and contents of the accepted APP/SSHP and Sections 01.B.02 and 28.D.03 of EM 385-1-1 . Each employee must sign a training log to acknowledge attendance and understanding of the training. Notify the Contracting Officer at least 5 days prior to the initial site-specific training session so government personnel involved in the project may attend.

1.10.3 Periodic Sessions

Conduct periodic onsite training by the SSHO at least weekly for personnel assigned to work at the site during the following week . Address safety and health procedures, work practices, any changes in the APP/SSHP, activity hazard analyses, work tasks, or schedule; results of previous week's air monitoring, review of safety discrepancies and accidents. Convene a meeting prior to implementation of the change must be convened should an operational change affecting onsite field work be made, to explain safety and health procedures. Conduct a site-specific training sessions for new personnel, visitors, and suppliers by the SSHO using the training curriculum outlines developed by the Safety and Health Manager. Each employee must sign a training log to acknowledge attendance and understanding of the training.

1.11 PERSONAL PROTECTIVE EQUIPMENT

1.11.1 Site Specific PPE Program

Provide onsite personnel exposed to contaminants with appropriate personal protective equipment. Components of levels of protection (B, C, D and modifications) must be relevant to site-specific conditions, including heat and cold stress potential and safety hazards. Use only respirators approved by NIOSH. Commercially available PPE, used to protect against chemical agent, must be approved by the director of Army Safety through the Chemical Agent Safety and Health Policy Action Committee (CASHPAC). Keep protective equipment and clothing clean and well maintained. Include site-specific procedures to determine PPE program effectiveness and for onsite fit-testing of respirators, cleaning, maintenance, inspection, and storage of PPE within the PPE section of the APP/SSHP.

1.11.2 Levels of Protection

The Safety and Health Manager must establish and evaluate as the work progresses the levels of protection for each work activity. Also establish action levels for upgrade or downgrade in levels of PPE. Describe in the SSHP the protocols and the communication network for changing the level of protection. Address air monitoring results, potential for exposure, changes in site conditions, work phases, job tasks, weather, temperature extremes, individual medical considerations, etc. within the PPE evaluation protocol.

1.11.2.1 Initial PPE Components

The following items constitute initial minimum protective clothing and equipment ensembles. Levels are defined in 29 CFR 1910, Subpart H.

a. Level D.

b. Level C.

c. Level B.

d. Level A.

1.12 MEDICAL SURVEILLANCE PROGRAM

Meet 29 CFR 1910.120/29 CFR 1926.65 (f) and the following requirements for medical surveillance program for workers performing cleanup operations and who will be exposed to contaminants. Assure the Occupational Physician or the physician's designee performs the physical examinations and reviews examination results. Participation in the medical surveillance program will be without cost to the employee, without loss of pay and at a reasonable time and place.

1.12.1 Frequency of Examinations

Medical surveillance program participants must receive medical examinations and consultations on the following schedule:

a. Every 12 months

b. If and when the participant develops signs and symptoms indicating a possible overexposure due to an uncontrolled release of a hazardous substance on the project.

c. Upon termination or reassignment to a job where medical surveillance program participation is not required, unless his/her previous annual examination/consultation was less than 6 months prior to reassignment or termination.

d. On a schedule specified by the occupational physician.

1.12.2 Content of Physical Examinations/Consultation

Verify the following information about medical surveillance program participants:

a. Baseline health conditions and exposure history.

b. Allergies/sensitivity/susceptibility to hazardous substances exposure.

c. Ability to wear personal protective equipment inclusive of NIOSH certified respirators under extreme temperature conditions.

d. Fitness to perform assigned duties.

Provide the occupational physician with the following information for each medical surveillance program participant:

a. Information on the employee's anticipated or measured exposure.

b. A description of any PPE used or to be used.

c. A description of the employee's duties as they relate to the employee's exposures (including physical demands on the employee and heat/cold stress).

d. A copy of 29 CFR 1910.120, or 29 CFR 1926.65.

e. Information from previous examinations not readily available to the examining physician.

f. A copy of Section 5.0 of NIOSH 85-115.

g. Information required by 29 CFR 1910 Section .134.

1.12.3 Physician's Written Opinion

Obtain and furnish to the Safety and Health Manager; and the employee before work begins, a copy of the physician's written opinion for each employee. Address the employee's ability to perform hazardous waste site remediation work and containing the following:

a. The physician's verification of the employee's fitness to perform duties as well as recommended limitations upon the employee's assigned work and/or PPE usage.

b. The physician's opinion about increased risk to the employee's health resulting from work; and

c. A statement that the employee has been informed and advised about the results of the examination.

1.12.4 Employee Certificates

Provided on employee certificates for each worker performing cleanup operations with potential for contaminant-related occupational exposure signed by the safety and health manager and the occupational physician indicating the workers meet the training and medical surveillance requirements of this contract.

1.13 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

Specify methods, instrument, and equipment for both direct reading (real-time) monitoring and integrated (time weighted average) sampling. Direct reading instruments may include the following, as appropriate: instruments for specific chemicals (colorimetric tubes, direct reading badges, hazardous gas monitors, oxygen meters, gas chromatographs); survey type instruments for gases or vapors (PID, FID, IR), total and respirable dust, radiation, flammable gases or vapors, noise, etc. Integrated sampling equipment may include the following, as appropriate: pumps, collection media, badge-type passive samplers, etc. Some methods may require specific types of sampling equipment. Specify the use of NIOSH methods (from NIOSH Publication Number 84-100, NIOSH Manual of Analytical Methods) for personal exposure sampling. Samples collected using NIOSH methods are to be analyzed only by laboratories currently accredited by the American Industrial Hygiene Association (AIHA). Address procedures and record keeping requirements for calibration and maintenance of instruments and equipment. Do not specify brand names for instruments or equipment. Specify requirements for evaluation of results and implementation of appropriate actions based upon action levels established by the hazard/risk analysis. Include a paragraph for requirements for reporting and documentation. Documentation is to include the following information: date, type of equipment utilized, equipment I.D. number, monitoring results for each work location or monitoring station with time of readings, analytical results for personal exposure sampling, personnel or location monitored/sampled with description of activity being performed, sample numbers, weather conditions (wind direction, precipitation, temperature, etc.), and miscellaneous information related to monitoring/sampling performed. The Safety and Health Manager shall prepare and implement an exposure monitoring/air sampling program to identify and quantify safety and health hazards and airborne levels of hazardous substances in order to assure proper selection of engineering controls, work practices and personal protective equipment for affected site personnel. Minimum initial requirements for the program are delineated below. Available site information shall be reviewed and the exposure monitoring/air sampling program shall be expanded and/or revised for submittal as part of the SSHP.

1.14 HEAT STRESS MONITORING AND MANAGEMENT

Document in the APP/SSHP and implement the procedures and practices in section 06.J. of EM 385-1-1 to monitor and manage heat stress.

1.15 MATERIALS TRANSFER SAFETY

Remove liquids and residues from the tanks using explosion-proof or air-driven pumps. Bond to the tank and ground pump motors and suction hoses to prevent electrostatic ignition hazards. Use of a hand pump will be permitted to remove the last of the liquid from the bottom of the tanks. If a vacuum truck is used for removal of liquids or residues, the area of operation for the vacuum truck must be vapor free. locate the truck upwind from the tank and outside the path of probable vapor travel. Discharge the vacuum pump exhaust gases through a hose of adequate size and length downwind of the truck and tank area. Vacuum truck operating and safety practices must conform to API RP 2219. Collect tank residues in drums, tanks, or tank trucks labeled according to 49 CFR 171 and 49 CFR 172 and disposed of as specified. Disconnect and drain fittings and lines of their contents after the materials have been transferred and the tanks have been exposed. Do not spill contents into the environment during cutting or disconnecting of tank fittings. Transfer materials drained into DOT-approved drums for storage and/or transportation. Only non-sparking or non-heat producing tools shall be used to disconnect and drain or to cut through tank fittings. Electrical equipment (e.g., pumps, portable hand tools, etc.) used for tank preparation must be explosion-proof. Following cutting or disconnecting of the fittings, plug openings leading to the tanks.

1.16 HOT WORK

Hot work will not be permitted on or within the tanks or anywhere else not previously specified as a hot work area, except as outlined herein. Prior to conducting hot work, a hot work permit must be prepared by the person to be conducting the hot work and reviewed and signed off by the Contractor's qualified person. An additional hot work permit may need to be obtained from local authorities or in the case of military or other federal installations, the fire marshal. An example format for a hot work permit must be included in the AAPP/SSHP. Describe compliance with the following procedures. After tank interiors have been decontaminated, hot work may be conducted only when the tank is made inert, and to the extent necessary to begin dismantling the tanks. After decontamination of tank interiors, hot work must not be performed unless monitoring indicates atmospheres within and immediately surrounding the tanks are less than 8% oxygen inside the tank and less than 10% of the LFL outside the tank; continuous monitoring must continue until the hot work is completed. The hot work prohibition includes welding, cutting, grinding, sawing, or other similar operations which could be expected to potentially generate combustion-producing temperatures or sparks, or which could produce potentially hazardous fumes or vapors. Designate an individual at each hot work site as a fire watch. This person's sole responsibility is to monitor the hot work and have immediate access to the fire extinguisher located at each hot work site. A new permit must be obtained at the start of each work shift during which hot work will be conducted.

1.17 SPILL AND DISCHARGE CONTROL

Develop and implement written spill and discharge containment/control procedures. Address radioactive wastes, shock sensitive wastes, laboratory waste packs, material handling equipment, as well as drum and container handling, opening, sampling, shipping and transport. Describe prevention measures, such as building berms or dikes; spill control measures and material to be used (e.g. booms, vermiculite); location of the spill control material; personal protective equipment required to cleanup spills; disposal of contaminated material; and who is responsible to report the spill. Storage of contaminated material or hazardous materials must be appropriately bermed, diked and/or contained to prevent any spillage of material on uncontaminated soil. If the spill or discharge is reportable, and/or human health or the environment are threatened, the National Response Center, the state, and the Contracting Officer must be notified as soon as possible. Reporting requirements must be in accordance with Section 02 65 00 UNDERGROUND STORAGE TANK REMOVAL.

1.18 ADDITIONAL SAFETY PROCEDURES, ENGINEERING CONTROLS, AND WORK PRACTICES

The SSHP shall describe the standard operating safety procedures, engineering controls and safe work practices to be implemented for the work covered. These shall include, but not be limited to, the following:

a. General site rules/prohibitions (buddy system, eating, drinking, and smoking restrictions, etc.).

b. Work Permit Requirements - Radioactive work, excavation, hot work, confined space, etc.

c. Written spill and discharge containment/control procedures. Address radioactive wastes, shock sensitive wastes, laboratory waste packs, material handling equipment, as well as drum and container handling, opening, sampling, shipping and transport. Describe prevention measures, such as building berms or dikes; spill control measures and material to be used (e.g. booms, vermiculite); location of the spill control material; personal protective equipment required to cleanup spills; disposal of contaminated material; and who is responsible to report the spill. Storage of contaminated material or hazardous materials must be appropriately bermed, diked and/or contained to prevent any spillage of material on uncontaminated soil. If the spill or discharge is reportable, and/or human health or the environment are threatened, the National Response Center, the state, and the Contracting Officer must be notified as soon as possible. Reporting requirements must be in accordance with Section 02 65 00 UNDERGROUND STORAGE TANK REMOVAL.

d. Drum and Container Handling - Procedures and precautions for opening, sampling, overpacking, etc.

e. Confined Space Entry Procedures

f. Ignition Sources

g. Fire Protection and Prevention

h. Electrical Safety

i. Excavation and Trench Safety

j. Guarding of Machinery and Equipment

k. Lockout/Tagout

l. Fall Protection

m. Hazard Communication

n. Illumination

o. Sanitation

p. Engineering Controls

q. Process Safety Management

r. Signs and Labels

s. Waste Disposal

1.19 TANK HANDLING

1.19.1 TANK PURGING FOR PERMIT-REQUIRED CONFINED SPACE ENTRIES

Purge tanks for confined space entry. Reduce the flammable vapors to less than 10% of the LFL and the oxygen content be between 19.5% and 23.5%. Do not attempt confined space entry into the tanks unless absolutely necessary, as for example, to remove sludge from the tank. Flammable vapors may be exhausted from the tank by any of the methods from API RP 1604 listed below, or any method approved by the Contracting Officer. Specify the purging method to be used within the APP/SSHP.

a. Ventilation by Eductor-Type Air Movers: Properly bond and ground the eductor-type air mover to prevent the generation and discharge of static electricity. When using this method, the fill (drop) tube must remain in place to ensure ventilation at the bottom of the tank. Tanks equipped with fill (drop) tubes that are not removable must be purged by this method. Use an eductor extension to discharge vapors a minimum of 3.7 m (12 feet) above grade or 1 m (3 feet) above adjacent roof lines, whichever is greater. If this is not possible, propose and get approved alternative methods prior to purging. Noise levels generated by these devices as a result of high airflow may exceed OSHA PEL. Evaluate noise levels and provide appropriate hearing protection.

b. Ventilation by Diffused Air Blowers: When using this purging method, the air-diffusing pipe is properly bonded and grounded to prevent the discharge of a spark. Fill (drop) tubes must be removed to allow proper diffusion of the air in the tank. Air supply must be from a compressor that has been checked to ensure that Grade D breathing air is being supplied. Air pressure in the tank must not exceed 34 kPa (5 psi) gauge to avoid tank failure.

c. Commercial Emulsifiers and Volatile Fuel Encapsulators: These products are completely miscible in water, aid in the elimination of flammable vapors, and are biodegradable. Determine prior to using this method, regulatory requirements for treatment and disposal of the water. Standing outside the tank, rinse the tank with a 3-to-6 percent solution of the product using a pressure sprayer through a tank opening. Measure explosive concentrations at several levels (top, middle, and bottom) within the tank. If readings are greater than 10% of the LFL, rinse the tank again. When LFL readings are acceptable, pump the water in the tank for disposal.

1.19.1.1 Monitoring to Ensure Purging

When monitoring to ensure purging, both oxygen content and LFL readings are required. Prior to obtaining LFL readings, monitor the oxygen content of the space and verify that the combustible gas indicators are operating within the oxygen limits identified by the CGI manufacturer. Do not permit personnel to enter spaces with oxygen levels are less than 19.5%, except in emergencies, and then only when equipped with the proper PPE and when following permit-required confined space entry procedures. Monitor toxic air contaminants as specified in paragraph EXPOSURE MONITORING/AIR SAMPLING PROGRAM.

1.19.2 MAKING TANKS INERT (NO ENTRY)

Following the removal of tank contents but prior to removal of the tank(s) and tank preparation activities, inert the tank(s) only by introducing an inert gas, carbon dioxide (CO2) or liquid nitrogen (N2), to remove flammable vapors. Before making inert, plug all openings in the tanks with threaded or expansion type plugs except the vent tube and the opening to be used for introducing the inert gas. Within 30 minutes prior to initiating any activities (e.g., excavating, preparation, removal, opening, demolition, transportation, or other similar activities) involving a tank which has been made inert, the inert nature of the tank (oxygen levels less than 8%) must be verified.

a. Do not use CO2 fire extinguishers for to make the tank interiors inert. If a compressed gas (e.g., CO2 or N2) is introduced into the tank the following requirements must be met to prevent the buildup of static electricity:

   (1) Bond together and ground the UST and the compressed gas supply tank.

   (2) Supply the compressed gas only at low flows.

   (3) Release the liquid or gas at the tank bottom so that static electricity is not generated by liquid falling to the bottom of the tank. Slowly fill the tank from the bottom up.

b. If used, introduce dry ice, which evolves CO2 gas as it evaporates, in the amount of at least 10 kg per 400 L (3 lbs per 100 gallons) of tank capacity. Prevent skin contact with dry ice by wearing heavy cloth gloves.

c. Introduce sufficient quantities of inert gas (CO2 or N2) into the tanks to lower the oxygen content to less than 8%. Do not exceed 34 kPa (5 psi) pressure inside the tank. Prior to proceeding with additional activities on the tank (e.g., excavating), the oxygen content of the tanks must be monitored to confirm that it is less than 8%. Conduct additional oxygen level monitoring at least hourly while activities involving the tanks are underway but prior to decontamination of tank interiors; at least daily during periods in which the tanks are not being disturbed but prior to decontamination of their interiors; or as directed by the Contracting Officer. If monitoring of tank interiors indicates that oxygen levels are not remaining below 8%, introduce additional inert gas and initiate more frequent oxygen monitoring.

d. During procedures to make tanks inert, use an extension vent tube a minimum of 3.7 m (12 feet) above grade or 1 m (3 feet) above any adjacent (within 22.5 m (75 feet)) roof lines, whichever is greater to discharge tank vapors. If this is not possible, propose and get approved alternative methods prior to making tank inert. Conduct continuous combustible gas/oxygen monitoring shall be conducted at the vent and inert gas introduction holes.

1.19.2.1 Monitoring to Ensure Tanks are Inert

Monitor tanks to ensure oxygen readings remain below a maximum allowable percentage of 8% by volume.

1.19.3 TANK ATMOSPHERE TESTING

Monitor the air within the storage tanks to ensure the space is both adequately purged and safe for personnel entry, or to ensure the tank has been made adequately inert and the oxygen content is less than 8%. In both instances, perform monitoring at the top, bottom, and middle areas of the tanks to ensure stratification has not occurred. Report monitoring results to project personnel to ensure safe operations. Record data as specified in paragraph EXPOSURE MONITORING/AIR SAMPLING PROGRAM.

1.19.4 TANK LIFTING

Lift tanks using equipment with a rated capacity greater than the load to be lifted. Lift tanks by lifting eyes or by straps under the ends of the tanks. Do not lift by the manhole flange or by removing the bungs. Direct personnel to remain away from the ends of the tanks and position tanks , whenever possible, with the ends oriented away from occupied or traveled areas, due to potential for rupture. During transportation, secure the tanks to prevent movement.

1.19.5 TANK DEMOLITION

Demolish excavated tanks before being removed from the site unless they are transported directly to a certified tank destruction facility. Demolition will not be permitted until a decontamination of the interiors and exteriors is complete. Demolition must involve opening the tanks sufficiently to permanently prohibit further use as containers of liquids. Tanks must be made inert and tested before they are opened. Submit plans and procedures in the APP/SSHP, including a list of materials and supplies, for safely and effectively demolishing the tanks.

1.19.6 TANK CLEANING

Conform to API Std 2015 for safety practices and procedures for the cleaning of the storage tanks. Conduct opening of the tanks to permit decontamination utilizing only methods approved in the APP/SSHP. Decontaminate the interior and exterior of the tank prior to removing it from the work site unless the tank is being transported directly to a state certified tank destruction facility. Submit plans and procedures in the SSHP, including materials and supplies, for safely and effectively opening the tanks, cleaning surfaces of the interior and exterior of the tanks, and disposing of the decontamination fluids. Volatile organic solvents are not permitted to be utilized for decontamination procedures. Personnel must not enter any of the storage tanks as a part of this project, except when following permit-required confined space entry procedures. Collect and dispose of decontamination fluids. Upon completion of this project, written certification must be made that the tank was properly decontaminated prior to being removed from the site.

1.20 SITE CONTROL MEASURES

1.20.1 Work Zones

Initial anticipated work zone boundaries (exclusion zone, contamination reduction zone, support zone, all access points and decontamination areas) are to be clearly delineated on the site drawings. Base delineation of work zone boundaries on the contamination characterization data and the hazard/risk analysis to be performed as described in paragraph: HAZARD/RISK ANALYSIS. As work progresses and field conditions are monitored, work zone boundaries may be modified (and site drawings modified) with approval of the Contracting Officer. Clearly identify work zones and marked in the field (using fences, tape, signs, etc.). Submit and post a site map, showing work zone boundaries and locations of decontamination facilities in the onsite office. Work zones must consist of the following:

a. Exclusion Zone (EZ): The exclusion zone is the area where hazardous contamination is either known or expected to occur and the greatest potential for exposure exists. Control entry into this area and exit may only be made through the CRZ.

b. Contamination Reduction Zone (CRZ): The CRZ is the transition area between the Exclusion Zone and the Support Zone. The personnel and equipment decontamination areas must be separate and unique areas located in the CRZ.

c. Support Zone (SZ): The Support Zone is defined as areas of the site, other than exclusion zones and contamination reduction zones, where workers do not have the potential to be exposed to hazardous substances or dangerous conditions resulting from hazardous waste operations. Secure the Support Zone against active or passive contamination. Site offices, parking areas, and other support facilities must be located in the Support Zone.

1.20.2 Site Control Log

A log of personnel visiting, entering, or working on the site must be maintained. Include the following: date, name, agency or company, time entering and exiting site, time entering and exiting the exclusion zone (if applicable). Before visitors are allowed to enter the Contamination Reduction Zone or Exclusion Zone, they must show proof of current training, medical surveillance and respirator fit testing (if respirators are required for the tasks to be performed) and fill out a Certificate of Worker or Visitor Acknowledgment. Record this visitor information, including date, in the log.

1.20.3 Communication

Provide and install an employee alarm system that has adequate means of on and off site communication in accordance with 29 CFR 1910 Section .165. The means of communication must be able to be perceived above ambient noise or light levels by employees in the affected portions of the workplace. The signals must be distinctive and recognizable as messages to evacuate or to perform critical operations.

1.20.4 Site Security

Provide the following site security: Print signs in bold large letters on contrasting backgrounds. Signs must be visible from all points where entry might occur and at such distances from the restricted area that employees may read the signs and take necessary protective steps before entering.

1.21 PERSONAL HYGIENE AND DECONTAMINATION

Personnel entering the Exclusion or Contamination Reduction Zones or otherwise exposed to hazardous chemical vapors, gases, liquids, or contaminated solids must decontaminate themselves and their equipment prior to exiting the contamination reduction zone (CRZ) and entering the support zone. Consult Chapter 10.0 of NIOSH 85-115 when preparing decontamination procedures. Submit a detailed discussion of personal hygiene and decontamination facilities and procedures to be followed by site workers as part of the APP/SSHP. Train employees in the procedures and enforce the procedures throughout site operations.

1.21.1 Decontamination Facilities

Submit drawings showing the layout of the personnel and equipment decontamination areas .

1.21.2 Personnel Decontamination

Initially set up a decontamination line in the CRZ. Employees must exit the exclusion zone through the CRZ and implement the following decontamination procedures and techniques: Scrub and rinse water proof outer garments, remove all outer garments, wash hands and face, and shower. Showers, if needed, must comply with 29 CFR 1910.141 and EM 385-1-1, 02 C, Washing Facilities. It is the Site Safety and Health Officer's responsibility to recommend techniques to improve personnel decontamination procedures, if necessary.

1.21.3 Equipment Decontamination

Decontaminate the vehicles and equipment used in the EZ shall be decontaminated in the CRZ prior to leaving the site.

1.21.3.1 Facilities for Equipment and Personnel

Provide a vehicle/equipment decontamination station within the CRZ for decontaminating vehicles and equipment leaving the EZ. Construct a decontamination station pad, which meets the site decontamination needs for all vehicles and larger equipment decontamination. Construct the pad to capture decontamination water, including overspray, and allow for collection and removal of the decontamination water using sumps, dikes and ditches as required. High pressure, low volume, water wash area for equipment and vehicles. A steam cleaning system for use after the mud and/or site material has been cleaned from the equipment. Dry decontamination using a broom to remove dry/loose spilled materials on accessible surfaces. A designated "clean area" in the CRZ for performing equipment maintenance. Use this area when personnel are required by normal practices to come in contact with the ground, i.e., crawling under a vehicle to change engine oil. Equipment within the EZ or CRZ must be decontaminated before maintenance is performed. .

1.21.3.2 Procedures

Procedures for equipment decontamination must be developed and utilized to prevent the spread of contamination into the SZ and offsite areas. These procedures must address disposal of contaminated products and spent materials used on the site, including containers, fluids, oils, etc. Assume any item taken into the EZ to be contaminated and perform an inspection and decontaminate. Vehicles, equipment, and materials must be cleaned and decontaminated prior to leaving the site. Handle construction material in such a way as to minimize the potential for contaminants being spread and/or carried offsite. Prior to exiting the site, vehicles and equipment must be monitored to ensure the adequacy of decontamination.

1.22 EMERGENCY EQUIPMENT AND FIRST AID REQUIREMENTS

Maintain, as a minimum, the following items onsite and available for immediate use:

a. First aid equipment and supplies approved by the consulting physician.

b. Emergency eyewashes and showers that comply with ANSI/ISEA Z358.1.

c. Emergency-use respirators. For escape purposes, supply 2 5- to 15-minute emergency escape masks. For rescue purposes, Supply positive pressure self-contained breathing apparatus (SCBA). Dedicate these for emergency use only and maintained onsite in the Contamination Reduction Zone.

d. Provide fire extinguishers of sufficient size and type at site facilities and in all vehicles and at any other site locations where flammable or combustible materials present a fire risk.

1.23 EMERGENCY RESPONSE AND CONTINGENCY PROCEDURES

An Emergency Response Plan, that meets the requirements of 29 CFR 1910.120 (l) and 29 CFR 1926.65 (l), must be developed and implemented as a section of the APP/SSHP. In the event of any emergency associated with remedial action, without delay, alert all onsite employees and as necessary offsite emergency responders that there is an emergency situation; take action to remove or otherwise minimize the cause of the emergency; alert the Contracting Officer; and institute measures necessary to prevent repetition of the conditions or actions leading to, or resulting in, the emergency. Train employees that are required to respond to hazardous emergency situations to their level of responsibility according to 29 CFR 1910.120 (q) and 29 CFR 1926.65 (q) requirements. Rehearse the plan regularly as part of the overall training program for site operations. Review the plan periodically and revised as necessary to reflect new or changing site conditions or information. Provide copies of the Emergency Response Portion of the accepted APP/SSHP to the affected local emergency response agencies. Address, as a minimum, the following elements in the plan:

a. Pre-emergency planning. Coordinate with local emergency response providers during preparation of the Emergency Response Plan. At a minimum, coordinate with local fire, rescue, hazardous materials response teams, police and emergency medical providers to assure all organizations are capable and willing to respond to and provide services for on-site emergencies. Ensure the Emergency Response Plan for the site is compatible and integrated with the local fire, rescue, medical and police security services available from local emergency response planning agencies.

b. Personnel roles, lines of authority, communications for emergencies.

c. Emergency recognition and prevention.

d. Site topography, layout, and prevailing weather conditions.

e. Criteria and procedures for site evacuation (emergency alerting procedures, employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control).

f. Specific procedures for decontamination and medical treatment of injured personnel.

g. Route maps to nearest prenotified medical facility. Site-support vehicles must be equipped with maps. At the beginning of project operations, drivers of the support vehicles must become familiar with the emergency route and the travel time required.

h. Emergency alerting and response procedures including posted instructions and a list of names and telephone numbers of emergency contacts (physician, nearby medical facility, fire and police departments, ambulance service, Federal, state, and local environmental agencies; as well as Safety and Health Manager, the Site Superintendent, the Contracting Officer and/or their alternates).

i. Criteria for initiating community alert program, contacts, and responsibilities.

j. Procedures for reporting incidents to appropriate government agencies. In the event that an incident such as an explosion or fire, or a spill or release of toxic materials occurs during the course of the project, the appropriate government agencies must be immediately notified. In addition, verbally notify the Contracting Officer and the local district safety office immediately and receive a written notification within 24 hours. Include within the report the following items:

(1) Name, organization, telephone number, and location of the Contractor.

(2) Name and title of the person(s) reporting.

(3) Date and time of the incident.

(4) Location of the incident, i.e., site location, facility name.

(5) Brief summary of the incident giving pertinent details including type of operation ongoing at the time of the incident.

(6) Cause of the incident, if known.

(7) Casualties (fatalities, disabling injuries).

(8) Details of any existing chemical hazard or contamination.

(9) Estimated property damage, if applicable.

(10) Nature of damage, effect on contract schedule.

(11) Action taken to ensure safety and security.

(12) Other damage or injuries sustained, public or private.

k. Procedures for critique of emergency responses and follow-up.

1.24 CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGEMENT

A copy of a Contractor-generated certificate of worker/visitor acknowledgement must be completed and submitted for each visitor allowed to enter contamination reduction or exclusion zones, and for each employee, following the example certificate at the end of this section.

1.25 INSPECTIONS

Attach to and submit with the Daily Quality Control reports the SSHO Daily Inspection Logs. Include with each entry the following: date, work area checked, employees present in work area, PPE and work equipment being used in each area, special safety and health issues and notes, and signature of preparer.

1.26 SAFETY AND HEALTH PHASE-OUT REPORT

Submit a Safety and Health Phase-Out Report in conjunction with the project close out report and will be received prior to final acceptance of the work. Include the following minimum information :

a. Summary of the overall performance of safety and health (accidents or incidents including near misses, unusual events, lessons learned, etc.).

b. Final decontamination documentation including procedures and techniques used to decontaminate equipment, vehicles, and on site facilities.

c. Summary of exposure monitoring and air sampling accomplished during the project.

d. Signatures of Safety and Health Manager and SSHO.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

Task Hazard and Control Requirements Sheet	
Task	
Initial Anticipated Hazards	
Initial PPE	
Initial Controls	
Initial Exposure Monitoring	

-- End of Section --

SECTION 01 42 00

SOURCES FOR REFERENCE PUBLICATIONS
11/14

PART 1 GENERAL

1.1 REFERENCES

Various publications are referenced in other sections of the specifications to establish requirements for the work. These references are identified in each section by document number, date and title. The document number used in the citation is the number assigned by the standards producing organization (e.g. ASTM B564 Standard Specification for Nickel Alloy Forgings). However, when the standards producing organization has not assigned a number to a document, an identifying number has been assigned for reference purposes.

1.2 ORDERING INFORMATION

The addresses of the standards publishing organizations whose documents are referenced in other sections of these specifications are listed below, and if the source of the publications is different from the address of the sponsoring organization, that information is also provided. Documents listed in the specifications with numbers which were not assigned by the standards producing organization should be ordered from the source by title rather than by number.

ACOUSTICAL SOCIETY OF AMERICA (ASA)
1305 Walt Whitman Road, Suite 300
Melville, NY 11747-4300
Ph: 516-576-2360
Fax: 631-923-2875
E-mail: asa@aip.org
Internet: http://asa.aip.org

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)
2800 Shirlington Road, Suite 300
Arlington, VA 22206
Ph: 703-575-4477
E-mail: info@acca.org
Internet: http://www.acca.org

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)
30 West University Drive
Arlington Heights, IL 60004-1893
Ph: 847-394-0150
Fax: 847-253-0088
E-mail: amca@amca.org
Internet: http://www.amca.org

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)
2111 Wilson Blvd, Suite 500
Arlington, VA 22201
Ph: 703-524-8800
Fax: 703-562-1942
Internet: http://www.ahrinet.org

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)
1200 G Street, NW, Suite 500
Washington, D.C. 20005
Ph: 202-628-6380
Fax: 202-393-5453
E-mail: kconn@atis.org
Internet: http://www.atis.org

ALUMINUM ASSOCIATION (AA)
National Headquarters
1525 Wilson Boulevard, Suite 600
Arlington, VA 22209
Ph: 703-358-2960
E-Mail: info@aluminum.org
Internet: http://www.aluminum.org

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)
1827 Walden Office Square, Suite 550
Schaumburg, IL 60173-4268
Ph: 847-303-5664
Fax: 847-303-5774
E-mail: customerservice@aamanet.org
Internet: http://www.aamanet.org

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)
444 North Capital Street, NW, Suite 249
Washington, DC 20001
Ph: 202-624-5800
Fax: 202-624-5806
E-Mail: info@aashto.org
Internet: http://www.aashto.org

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)
1 Davis Drive
P.O. Box 12215
Research Triangle Park, NC 27709-2215
Ph: 919-549-8141
Fax: 919-549-8933
Internet: http://www.aatcc.org

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)
2025 M Street, NW, Suite 800
Washington, DC 20036
Ph: 202-367-1155
E-mail: info@americanbearings.org
Internet: http://www.americanbearings.org

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)
38800 Country Club Drive
Farmington Hills, MI 48331-3439
Ph: 248-848-3700
Fax: 248-848-3701
E-mail: bkstore@concrete.org
Internet: http://www.concrete.org

AMERICAN CONCRETE PIPE ASSOCIATION (ACPA)
8445 Freeport Parkway, Suite 350

Irving, TX 75063-2595
Ph: 972-506-7216
Fax: 972-506-7682
E-mail: info@concrete-pipe.org
Internet: http://www.concrete-pipe.org

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)
1330 Kemper Meadow Drive
Cincinnati, OH 45240
Ph: 513-742-2020 or 513-742-6163
Fax: 513-742-3355
E-mail: mail@acgih.org
Internet: http://www.acgih.org

AMERICAN FOREST AND PAPER ASSOCIATION (AF&PA)
American Wood Council
ATTN: Publications Department
1111 Nineteenth Street NW, Suite 800
Washington, DC 20036
Ph: 800-890-7732 or 202-463-2766
Fax: 202-463-2791
E-mail: awcpubs@afandpa.org
Internet: http://www.awc.org/

AMERICAN GAS ASSOCIATION (AGA)
400 North Capitol Street N.W.
Suite 450
Washington, D.C. 20001
Ph: 202-824-7000
Internet: http://www.aga.org

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)
1001 N. Fairfax Street, Suite 500
Alexandria, VA 22314-1587
Ph: 703-684-0211
Fax: 703-684-0242
E-mail: tech@agma.org
Internet: http://www.agma.org

AMERICAN HARDBOARD ASSOCIATION (AHA)
1210 West Northwest Highway
Palatine, IL 60067
Ph: 847-934-8800
Fax: 847-934-8803
E-mail: aha@hardboard.org
Internet: http://domensino.com/AHA/

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA)
3141 Fairview Park Dr, Suite 777
Falls Church, VA 22042
Tel: 703-849-8888
Fax: 703-207-3561
E-mail: infonet@aiha.org
Internet http://www.aiha.org

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)
One East Wacker Drive, Suite 700
Chicago, IL 60601-1802
Ph: 312-670-2400

Fax: 312-670-5403
Bookstore: 800-644-2400
E-mail: aisc@ware-pak.com
Internet: http://www.aisc.org

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION (AITC)
7012 South Revere Parkway, Suite 140
Centennial, CO 80112
Ph: 503-639-0651
Fax: 503-684-8928
E-mail: info@aitc-glulam.org
Internet: http://www.aitc-glulam.org

AMERICAN IRON AND STEEL INSTITUTE (AISI)
25 Massachusetts Avenue, NW Suite 800
Washington, DC 20001
Ph: 202-452-7100
Internet: http://www.steel.org

AMERICAN LUMBER STANDARDS COMMITTEE (ALSC)
P.O. Box 210
Germantown, MD 20875-0210
Ph: 301-972-1700
Fax: 301-540-8004
E-mail: alsc@alsc.org
Internet: http://www.alsc.org

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
1899 L Street, NW,11th Floor
Washington, DC 20036
Ph: 202-293-8020
Fax: 202-293-9287
E-mail: storemanager@ansi.org
Internet: http://www.ansi.org/

AMERICAN PETROLEUM INSTITUTE (API)
Internet: http://www.api.org

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)
4501 Forbes Blvd., Suite 130
Lanham, MD 20706
Ph: 301-459-3200
Fax: 301-459-8077
E-mail: bcaruso@arema.org
Internet: http://www.arema.org

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)
P.O. Box 28518
1711 Arlingate Lane
Columbus, OH 43228-0518
Ph: 800-222-2768; 614-274-6003
Fax: 614-274-6899
E-mail: tjones@asnt.org
Internet: http://www.asnt.org

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)
1801 Alexander Bell Drive
Reston, VA 20191

Ph: 703-295-6300; 800-548-2723
E-mail: member@asce.org
Internet: http://www.asce.org

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)
1791 Tullie Circle, NE
Atlanta, GA 30329
Ph: 800-527-4723 or 404-636-8400
Fax: 404-321-5478
E-mail: ashrae@ashrae.org
Internet: http://www.ashrae.org

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)
1800 East Oakton Street
Des Plaines, IL 60018
Ph: 847-699-2929
Internet: http://www.asse.org

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)
18927 Hickory Creek Drive, Suite 220
Mokena, IL 60448
Ph: 708-995-3019
Fax: 708-479-6139
E-mail: staffengineer@asse-plumbing.org
Internet: http://www.asse-plumbing.org

AMERICAN WATER WORKS ASSOCIATION (AWWA)
6666 West Quincy Avenue
Denver, CO 80235-3098
Ph: 303-794-7711
E-mail: distribution@awwa.org
Internet: http://www.awwa.org

AMERICAN WELDING SOCIETY (AWS)
13301 NW 47 Ave
Miami, FL 33054

Ph: 888-WELDING, 305-824-1177, 305-826-6192
Fax: 305-826-6195
E-mail: customer.service@awspubs.com
Internet: http://www.aws.org

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)
P.O. Box 361784
Birmingham, AL 35236-1784
Ph: 205-733-4077
Fax: 205-733-4075
Internet: http://www.awpa.com

AmericanHort (AH)
2130 Stella Court
Columbus, OH 43215 USA
Ph: 614-487-1117
Fax: 614-487-1216
E-mail: hello@AmericanHort.org
Internet: http://americanhort.org/AmericanHort/AmericanHort

APA - THE ENGINEERED WOOD ASSOCIATION (APA)
7011 South 19th St.
Tacoma, WA 98466-5333
Ph: 253-565-6600
Fax: 253-565-7265
Internet: http://www.apawood.org

ARCHITECTURAL WOODWORK INSTITUTE (AWI)
46179 Westlake Drive, Suite 120
Potomac Falls, VA 20165
Ph: 571-323-3636
Fax: 571-323-3630
E-mail: info@awinet.org
Internet: http://www.awinet.org

ARCNET TRADE ASSOCIATION (ATA)
E-mail: info@arcnet.com
Internet: http://www.arcnet.com/index.htm</URL

ASME INTERNATIONAL (ASME)
Two Park Avenue, M/S 10E
New York, NY 10016-5990
Ph: 800-843-2763
Fax: 973-882-1717
E-mail: customercare@asme.org
Internet: http://www.asme.org

ASPHALT INSTITUTE (AI)
2696 Research Park Drive
Lexington, KY 40511-8480
Ph: 859-288-4960
Fax: 859-288-4999
E-mail: info@asphaltinstitute.org
Internet: http://www.asphaltinstitute.org

ASSOCIATED AIR BALANCE COUNCIL (AABC)
1518 K Street, NW
Washington, DC 20005
Ph: 202-737-0202
Fax: 202-638-4833
E-mail: info@aabc.com
Internet: http://www.aabc.com/

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)
600 North 18th Street
P.O. Box 2641
Birmingham, AL 35291-0992
Ph: 205-257-3839
E-Mail: aeicdir@bellsouth.net
Internet: http://www.aeic.org

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS (AHAM)
1111 19th Street NW, Suite 402
Washington, DC 20036
Ph: 202-872-5955
E-mail: info@aham.org
Internet: http://www.aham.org

ASSOCIATION OF THE WALL AND CEILING INDUSTRY (AWCI)
513 West Broad Street, Suite 210
Falls Church, VA 22046
Ph: 703-538-1600
Fax: 703-534-8307
E-mail: info@awci.org
Internet: http://www.awci.org

ASTM INTERNATIONAL (ASTM)
100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA 19428-2959
Ph: 877-909-2786
Internet: http://www.astm.org

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)
355 Lexington Avenue, 15th Floor
New York, NY 10017
Ph: 212-297-2122
Fax: 212-370-9047
Internet: http://www.buildershardware.com

CALIFORNIA ENERGY COMMISSION (CEC)
Media and Public Communications Office
1516 Ninth Street, MS-29
Sacramento, CA 95814-5512
Ph: 916-654-5106
E-mail: appliances@energy.ca.gov
Internet: http://www.energy.ca.gov/

CARPET AND RUG INSTITUTE (CRI)
P.O. Box 2048
Dalton, GA 30722-2048
Ph: 706-278-3176
Fax: 706-278-8835
Internet: http://www.carpet-rug.com

CAST IRON SOIL PIPE INSTITUTE (CISPI)
3008 Preston Station Drive
Hixson, TN 37343
Ph: 423-842-2122
Internet: http://www.cispi.org

CEILINGS AND INTERIOR SYSTEMS CONSTRUCTION ASSOCIATION (CISCA)
1010 Jorie Blvd, Suite 30
Oak Brook, IL 60523
Ph: 630-584-1919
Fax: 866-560-8537
E-mail: cisca@cisca.org
Internet: http://www.cisca.org

COMPOSITE PANEL ASSOCIATION (CPA)
19465 Deerfield Avenue, Suite 306
Leesburg, VA 20176
Ph: 703-724-1128
Fax: 703-724-1588
Internet: http://www.compositepanel.org/

COMPRESSED AIR AND GAS INSTITUTE (CAGI)
1300 Sumner Avenue

Cleveland OH 44115-2851
Ph: 216-241-7333
Fax: 216-241-0105
E-mail: cagi@cagi.org
Internet: http://www.cagi.org/

COMPRESSED GAS ASSOCIATION (CGA)
14501 George Carter Way, Suite 103
Chantilly, VA 20151-1788
Ph: 703-788-2700
Fax: 703-961-1831
E-mail: cga@cganet.com
Internet: http://www.cganet.com

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)
933 North Plum Grove Road
Schaumburg, IL 60173-4758
Ph: 847-517-1200
Fax: 847-517-1206
Internet: http://www.crsi.org/

CONSUMER ELECTRONICS ASSOCIATION (CEA)
1919 South Eads St.
Arlington, VA 22202
Ph: 866-858-1555 or 703-907-7634
Fax: 866-858-2555 or 703-907-7693
E-mail: standards@CE.org
Internet: http://www.CE.org

CONSUMER PRODUCT SAFETY COMMISSION (CPSC)
4330 East-West Highway
Bethesda, MD 20814
Ph: 301-504-7923
Fax: 301-504-0124 or 301-504-0025
Internet: http://www.cpsc.gov

COOLING TECHNOLOGY INSTITUTE (CTI)
P.O. Box 73383
Houston, TX 77273-3383
Ph: 281-583-4087
Fax: 281-537-1721
E-mail: vmanser@cti.org
Internet: http://www.cti.org

COPPER DEVELOPMENT ASSOCIATION (CDA)
Internet: http://www.copper.org

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)
8720 Red Oak Boulevard, Suite 201
Charlotte, NC 28217-3992
Ph: 704-676-1190
Fax: 704-676-1199
Internet: http://www.mhi.org/cmaa

CSA GROUP (CSA)
178 Rexdale Blvd.
Toronto, ON, Canada M9W 1R3
Ph: 416-747-4044
Fax: 416-747-2510

E-mail: sales@csagroup.org
Internet: http://www.csagroup.org/us/en/home

DOOR AND ACCESS SYSTEM MANUFACTURERS ASSOCIATION (DASMA)
1300 Sumner Avenue
Cleveland, OH 44115-2851
Ph: 216-241-7333
Fax: 216-241-0105
Internet: http://www.dasma.com

DUCTILE IRON PIPE RESEARCH ASSOCIATION (DIPRA)
1322 Riverhaven Place
Birmingham, AL 35244
Ph: 205-402-8700
Internet: http://www.dipra.org

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)
1650 South Dixie Highway, Suite 400
Boca Raton, FL 33432-7462
Ph: 561-750-5575
Fax: 561-395-8557
Internet: http://www.egsa.org

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)
2214 Rock Hill Rd., Suite 170
Herndon, VA 20170
Ph: 571-323-0294
Fax: 571-323-0245
E-mail: emikoski@ecaus.org
Internet: http://www.ecianow.org/

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)
25 North Broadway
Tarrytown, NY 10591
Fax: 914-332-1541
E-mail: inquiries@ejma.org
Internet: http://www.ejma.org

FLUID CONTROLS INSTITUTE (FCI)
1300 Sumner Avenue
Cleveland, OH 44115
Ph: 216-241-7333
Fax: 216-241-0105
E-mail: fci@fluidcontrolsinstitute.org
Internet: www.fluidcontrolsinstitute.org

FM GLOBAL (FM)
270 Central Avenue
P.O. Box 7500
Johnston, RI 02919-4923
Ph: 877-364-6726
Fax: 401-275-3029
E-mail: servicedesk.myrisk@fmglobal.com
Internet: http://www.fmglobal.com

FOREST STEWARDSHIP COUNCIL (FSC)
212 Third Avenue North
Suite 445
Minneapolis, MN 55401

Ph: 612-353-4511
E-mail: info@us.fcs.org
Internet: https://us.fsc.org/

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)
University of South California
Research Annex 219
3716 South Hope Street
Los Angeles, CA 90089-7700
Ph: 213-740-2032 or 866-545-6340
Fax: 213-740-8399
E-mail: fccchr@usc.edu
Internet: http://www.usc.edu/dept/fccchr

GERMAN INSTITUTE FOR STANDARDIZATION (DIN)
Americas
Englewood, CO, US
Ph: +1 800-447-2273 (Toll Free), +1 303-736-3001 (US/Canada)
Internet:

GLASS ASSOCIATION OF NORTH AMERICA (GANA)
800 SW Jackson St., Suite 1500
Topeka, KS 66612-1200
Ph: 785-271-0208
E-mail: gana@glasswebsite.com
Internet: http://www.glasswebsite.com

GREEN SEAL (GS)
1001 Connecticut Avenue, NW
Suite 827
Washington, DC 20036-5525
Ph: 202-872-6400
Fax: 202-872-4324
Internet: http://www.greenseal.org

GYPSUM ASSOCIATION (GA)
6525 Belcrest Road, Suite 480
Hyattsville, MD 20782
Ph: 301-277-8686
Fax: 301-277-8747
E-mail: info@gypsum.org
Internet: http://www.gypsum.org

HARDWOOD PLYWOOD AND VENEER ASSOCIATION (HPVA)
1825 Michael Faraday Dr.
Reston, VA 20190
Ph: 703-435-2900
Fax: 703-435-2537
E-mail: hpva@hpva.org
Internet: http://www.hpva.org

HYDRAULIC INSTITUTE (HI)
6 Campus Drive, First Floor North
Parsippany, NJ 07054-4406
Ph: 973-267-9700
Fax: 973-267-9055
Internet: http://www.pumps.org

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)
35 Russo Place
P.O. Box 218
Berkeley Heights, NJ 07922-0218
Ph: 908-464-8200
Fax: 908-464-7818
Internet: http://www.ahrinet.org

ICC EVALUATION SERVICE, INC. (ICC-ES)
3060 Saturn Street, Suite 100
Brea, CA 92821
Ph: 800-423-6587 ext. 66546
Fax: 562-695-4694
E-mail: es@icc-es.org
Internet: http://www.icc-es.org

ILLUMINATING ENGINEERING SOCIETY (IES)
120 Wall Street, 17th Floor
New York, NY 10005-4001
Ph: 212-248-5000
Fax: 212-248-5018
E-mail: IES@IES.org
Internet: http://www.IES.org

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
445 and 501 Hoes Lane
Piscataway, NJ 08854-4141
Ph: 732-981-0060 or 800-701-4333
Fax: 732-562-9667
E-mail: onlinesupport@ieee.org
Internet: http://www.ieee.org

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)
2340 South Arlington Heights Rd. Suite 620
Arlington Heights, IL 60005-4510
Ph: 847-981-0100
Fax: 847-981-4130
E-mail: information@iest.org
Internet: http://www.iest.org

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)
P.O. Box 1568
Carrollton, GA 30112
E-mail:
http://www.icea.net/Public_Pages/Contact/Email_Contact.html
Internet: http://www.icea.net

INSULATING GLASS MANUFACTURERS ALLIANCE (IGMA)
27 N. Wacker Dr. Suite 365
Chicago, IL 60606-2800
Ph: 613-233-1510
Fax: 613-482-9436
E-mail: enquiries@igmaonline.org
Internet: http://www.igmaonline.org

INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)
800 Place Victoria
PO Box 113

Montréal, Quebec, H4Z 1M1
Ph: 514-390-6726 or 800-716-6326
Fax: 514-874-9659
E-mail: custserv@iata.org
Internet: http://www.iata.org

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)
4755 E. Philadelphia St.
Ontario, CA 91761
Ph: 909-472-4100
Fax: 909-472-4150
E-mail: iapmo@iapmo.org
Internet: http://www.iapmo.org

INTERNATIONAL CODE COUNCIL (ICC)
500 New Jersey Avenue, NW
6th Floor, Washington, DC 20001
Ph: 800-786-4452 or 888-422-7233
E-mail: order@iccsafe.org
Internet: www.iccsafe.org

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)
3050 Old Centre Ave. Suite 102
Portage, MI 49024
Ph: 269-488-6382
Internet: http://www.netaworld.org

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
3, rue de Varembe
P.O. Box 131
CH-1211 Geneva 20, Switzerland
Ph: 41-22-919-02-11
Fax: 41-22-919-03-00
Internet: http://www.iec.ch

INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION (IIAR)
1001 N. Fairfax Street, Suite 503
Alexandria, VA 22314
Ph: 703-312-4200
Fax: 703-312-0065
E-mail: iiar_request@iiar.org
Internet: http://www.iiar.org

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
1, ch. de la Voie-Creuse
Case Postale 56
CP 56 - CH-1211 Geneva 20
Switzerland
Ph: 41-22-749-01-11
Fax: 41-22-733-34-30
E-mail: central@iso.ch
Internet: http://www.iso.org

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)
1901 North Moore Street
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Ph: 703-525-1695
Fax: 703-528-2148

Internet: http://www.safetyequipment.org/

INTERNATIONAL WINDOW CLEANING ASSOCIATION (IWCA)
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Zanesville, OH 43701-7303
Ph: 800-875-4922
E-mail: info@iwca.org
Internet: http://www.iwca.org

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)
67 T.W. Alexander Drive
PO Box 12277
Research Triangle Park, NC 27709
Ph: 919-549-8411
Fax: 919-549-8288
E-mail: info@isa.org
Internet: http://www.isa.org

INTERNET ENGINEERING TASK FORCE (IETF)
c/o Association Management Solutions, LLC (AMS)
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Glen Ellyn, IL 60137
Ph: 630-942-6591
Fax: 630-790-3095

E-mail: wlewis7@cox.net(Wes Lewis,technical consultant)
Internet: http://www.naamm.org

NATIONAL CABLE AND TELECOMMUNICATIONS ASSOCIATION (NCTA)
25 Massachusetts Avenue, NW, Suite 100
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Internet: http://www.ncta.com

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Fax: 301-215-4500
Internet: http://www.necanet.org/

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
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Fax: 301-977-9589
Internet: http://www.nebb.org

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Greenbelt, MD 20770
Ph: 301-589-1776
Fax: 301-589-3884
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Internet: http://www.nfrc.org

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
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Quincy, MA 02169-7471
Ph: 617-770-3000
Fax: 617-770-0700
Internet: http://www.nfpa.org

NATIONAL HARDWOOD LUMBER ASSOCIATION (NHLA)
6830 Raleigh LaGrange Road
PO Box 34518
Memphis, TN 38184
Ph: 901-377-1818
Store: 901-399-7563
Internet: http://www.nhla.org

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)
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Internet: http://www.nicet.org

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)
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Washington, DC 20201
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NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)
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Manager, Customer Service
900 Spring Street
Silver Spring, MD 20910
Ph: 240-485-1165
E-mail: jjenkins@nrmca.org (Jacques Jenkins)
Internet: http://www.nrmca.org

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Internet: http://www.nrca.net

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)
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E-Mail: ris@calredwood.org
Internet: http://www.redwoodinspection.com/

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SCIENTIFIC EQUIPMENT AND FURNITURE ASSOCIATION (SEFA)
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Garden City, N.Y. 11530
Ph: 516-294-5424
Fax: 516-294-4765
E-mail: info@sefalabs.com
Internet: http://www.sefalabs.com

SCREEN MANUFACTURERS ASSOCIATION (SMA)
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E-mail: Kathryn@SMAinfo.org
Internet: http://smainfo.org

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)
4201 Lafayette Center Drive
Chantilly, VA 20151-1219
Ph: 703-803-2980
Fax: 703-803-3732
Internet: http://www.smacna.org

SOCIETY FOR PROTECTIVE COATINGS (SSPC)
40 24th Street, 6th Floor
Pittsburgh, PA 15222
Ph: 412-281-2331
Fax: 412-281-9992
E-mail: info@sspc.org
Internet: http://www.sspc.org

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)
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Warrendale, PA 15096
Ph: 724-776-4970
Fax: 877-606-7323
E-mail: customerservice@sae.org
Internet: http://www.sae.org

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)
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Fax: 412.487.3326
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Internet: http://www.sdi.org

STEEL DOOR INSTITUTE (SDI/DOOR)
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Westlake, OH 44145
Ph: 440-899-0010
Fax: 440-892-1404
E-mail: info@steeldoor.org
Internet: http://www.steeldoor.org

STEEL JOIST INSTITUTE (SJI)
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Florence, SC 29501
Ph: 843-407-4091
Internet: http://www.steeljoist.org

STEEL TANK INSTITUTE (STI)
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Ph: 847-438-8265
Fax: 847-438-8766
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TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)
15 Technology Parkway South, Suite 115
Peachtree Corners, GA 30092
Ph: 800-322-8686 or 770-446-1400
Fax: 770-446-6947
E-mail: memberconnection@tappi.org
Internet: http://www.tappi.org

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Ph: 703-907-7700
Fax: 703-907-7727
Internet: http://www.tiaonline.org

TILE COUNCIL OF NORTH AMERICA (TCNA)
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Anderson, SC 29625
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Fax: 864-646-2821
E-mail: info@tileusa.com
Internet: http://www.tcnatile.com/

TREE CARE INDUSTRY ASSOCIATION (TCIA)
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Londonderry, NH 03053
Ph: 603-314-5380
Fax: 603-314-5386
Internet: http://tcia.org/

TRUSS PLATE INSTITUTE (TPI)
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Alexandria, VA 22314
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Fax: 866-501-4012
E-mail: info@tpinst.org
Internet: http://www.tpinst.org

TURFGRASS PRODUCERS INTERNATIONAL (TPI)
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East Dundee, IL 60118
Ph: 847-649-5555
Fax: 847-649-5678
E-mail: info@turfgrasssod.org
Internet: http://www.turfgrasssod.org

U.S. ARMY (DA)
U.S. Army Publishing Directorate
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Internet: http://www.apd.army.mil

U.S. ARMY CORPS OF ENGINEERS (USACE)
CRD-C DOCUMENTS available on Internet:
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Internet: http://www.publications.usace.army.mil/
or
http://www.hnc.usace.army.mil/Missions/Engineering/TECHINFO.aspx

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Internet: http://assist.daps.dla.mil/online/start/; account

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Obtain Unified Facilities Criteria (UFC) from:
Whole Building Design Guide (WBDG)
National Institute of Building Sciences (NIBS)
1090 Vermont Avenue NW, Suite 700
Washington, CD 20005
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Fax: 202-289-1092
Internet: http://www.wbdg.org/references/docs_refs.php

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)
HUD User
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Washington, DC 20026-3268
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Fax: 202-708-9981
Internet: http://www.huduser.org

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Alexandria, VA 22312
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U.S. FORCES, KOREA (USFK)
Internet:
HREF=http://8tharmy.korea.army.mil/g1_AG/Programs_Policy/Publication_Records_F

U.S. GENERAL SERVICES ADMINISTRATION (GSA)
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Washington, D.C. 20037
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Internet: http://www.usgbc.org

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UL ENVIRONMENT (ULE)
2211 Newmarket Parkway, Suite 106
Marietta, GA 30067
Ph: 770-933-0638
Fax: 770-980-0072
E-mail: environment@ul.com
Intertet: http://www.ul.com/environment

UNDERWRITERS LABORATORIES (UL)
2600 N.W. Lake Road
Camas, WA 98607-8542
Ph: 877-854-3577
E-mail: CEC.us@us.ul.com
Internet: http://www.ul.com/
UL Directories available through IHS at http://www.ihs.com

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2711 LBJ Freeway, Suite 1000
Dallas, TX 75234
Ph: 972-243-3902
Fax: 972-243-3907
E-mail: info@uni-bell.org
Internet: http://www.uni-bell.org

WEST COAST LUMBER INSPECTION BUREAU (WCLIB)
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Internet: http://www.wclib.org

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)
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WINDOW AND DOOR MANUFACTURERS ASSOCIATION (WDMA)
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WOOD MOULDING AND MILLWORK PRODUCERS ASSOCIATION (WMMPA)
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Woodland, CA 95695
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E-mail: info@wmmpa.com
Internet: http://www.wmmpa.com

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Fax: 61 2 8295 4100
E-mail: feedback@wool.com
internet: http://www.woolmark.com

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

Not used

-- End of Section --

SECTION 01 45 00.00 10

QUALITY CONTROL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 3740	(2010) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM E 329	(2010) Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with this section.

SD-01 Preconstruction Submittals

Quality Control Plan; G

1.3 PAYMENT

Separate payment will not be made for providing and maintaining an effective Quality Control program, and all associated costs will be included in the applicable Bid Schedule unit or lump-sum prices.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Establish and maintain an effective quality control (QC) system in compliance with the Contract Clause titled "Inspection of Construction." QC consists of plans, procedures, and organization necessary to produce an end product which complies with the contract requirements. Cover all construction operations, both onsite and offsite, and be keyed to the proposed construction sequence. The project superintendent will be held responsible for the quality of work and is subject to removal by the

Contracting Officer for non-compliance with the quality requirements specified in the contract. In this context the highest level manager responsible for the overall construction activities at the site, including quality and production is the project superintendent. The project superintendent must maintain a physical presence at the site at all times and is responsible for all construction and related activities at the site, except as otherwise acceptable to the Contracting Officer.

3.2 QUALITY CONTROL PLAN

Submit no later than 15 days after receipt of notice to proceed, the Contractor Quality Control (CQC) Plan proposed to implement the requirements of the Contract Clause titled "Inspection of Construction." The Government will consider an interim plan for the first 15 days of operation. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of work to be started. Work outside of the accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional work.

3.2.1 Content of the CQC Plan

Include, as a minimum, the following to cover all construction operations, both onsite and offsite, including work by subcontractors, fabricators, suppliers, and purchasing agents:

a. A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff will implement the three phase control system for all aspects of the work specified.

b. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.

c. A copy of the letter to the CQC System Manager signed by an authorized official of the firm which describes the responsibilities and delegates sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop work which is not in compliance with the contract. Letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities will be issued by the CQC System Manager. Copies of these letters must be furnished to the Government.

d. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers, and purchasing agents. These procedures must be in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

e. Control, verification, and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test. (Laboratory facilities approved by the Contracting Officer must be used.)

f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests including documentation.

g. Procedures for tracking construction deficiencies and schedule delays from identification through acceptable corrective action. Establish verification procedures that identified deficiencies have been corrected.

h. Reporting procedures, including proposed reporting formats.

i. A list of the definable features of work. A definable feature of work is a task which is separate and distinct from other tasks, has separate control requirements, and may be identified by different trades or disciplines, or it may be work by the same trade in a different environment. Although each section of the specifications may generally be considered as a definable feature of work, there is frequently more than one definable feature under a particular section. This list will be agreed upon during the coordination meeting.

k. Inspections procedures (to include controls, verification, checks, reviews and examinations) for each specific feature of work to include the inspection name, control phase (as defined in 3.6), specification paragraph requiring the inspection or drawing number, submittal number, feature of work to be inspected, inspection frequency, and person responsible for each inspection.

3.2.2 Acceptance of Plan

Acceptance of the Contractor's plan is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. The Government reserves the right to require the Contractor to make changes in his CQC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.

3.2.3 Notification of Changes

After acceptance of the CQC Plan, notify the Contracting Officer in writing of any proposed change. Proposed changes are subject to acceptance by the Contracting Officer.

3.3 COORDINATION MEETING

After the Preconstruction Conference, before start of construction, and prior to acceptance by the Government of the CQC Plan, meet with the Contracting Officer or Authorized Representative and discuss the Contractor's quality control system. Submit the CQC Plan a minimum of 14 calendar days prior to the Coordination Meeting. During the meeting, a mutual understanding of the system details must be developed, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite work, and the interrelationship of Contractor's Management and control with the Government's Quality Assurance. Minutes of the meeting will be prepared by the Government, signed by both the Contractor and the Contracting Officer and will become a part of the contract file. There may be occasions when subsequent conferences will be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures which may require corrective action by the Contractor.

3.4 QUALITY CONTROL ORGANIZATION

3.4.1 Personnel Requirements

The requirements for the CQC organization are a CQC System Manager and sufficient number of additional qualified personnel to ensure safety and contract compliance. Personnel identified in the technical provisions as requiring specialized skills to assure the required work is being performed properly will also be included as part of the CQC organization. The Contractor's CQC staff must maintain a presence at the site at all times during progress of the work and have complete authority and responsibility to take any action necessary to ensure contract compliance. The CQC staff will be subject to acceptance by the Contracting Officer. Provide adequate office space, filing systems and other resources as necessary to maintain an effective and fully functional CQC organization. Promptly complete and furnish all letters, material submittals, shop drawing submittals, schedules and all other project documentation to the CQC organization. The CQC organization shall be responsible to maintain these documents and records at the site at all times, except as otherwise acceptable to the Contracting Officer.

3.4.2 CQC System Manager

Identify as CQC System Manager an individual within the onsite work organization who is responsible for overall management of CQC and have defined authority, responsibility and accountability for ensuring that the requirements of this standard are implemented and maintained. The CQC System Manager must be a licensed engineer with a minimum of 5 years construction experience on construction similar to this contract. This CQC System Manager must be on the site at all times during construction and be employed by the prime Contractor. The CQC System Manager must be assigned no other duties. Identify in the plan an alternate to serve in the event of the CQC System Manager's absence. The requirements for the alternate are the same as the CQC System Manager. CQC System Manager and the Alternate CQC System Manager must have attended the course "Construction Quality Management for Contractors" as part of their qualifications. CQC System Manager and Alternate CQC System Manager must be currently trained (within the previous 5 years period) or scheduled for the next course with written waiver documentation from the contractor for the Resident Engineer's acceptance. CQC System Manager may not serve with a Certificate/Training document more than 6 months past the 5-year expiration date.

3.4.3 CQC Personnel

In addition to CQC personnel specified elsewhere in the contract, provide as part of the CQC organization specialized personnel to assist the CQC System Manager for the following areas: electrical, mechanical, civil, structural, environmental, architectural, materials technician, and submittals clerk. These individuals must be directly employed by the prime Contractor and may not be employed by a supplier or subcontractor on this project; be responsible to the QC System Manager; be physically present at the construction site during work on their areas of responsibility; have the necessary education and/or experience in accordance with the experience matrix listed herein. These individuals may perform other duties but must be allowed sufficient time to perform their assigned quality control duties as described in the Quality Control Plan.

Experience Matrix	
Area	Qualifications
Civil	Licensed Civil Engineer with 2 years experience in the type of work being performed on this project or engineering technician with 5 years related experience.
Mechanical	Licensed Mechanical Engineer with 2 years experience in the type of work being performed on this project or engineering technician with 5 years experience supervising mechanical features of work in the field with a construction company.
Electrical	Licensed Electrical Engineer with 2 years experience in the type of work being performed on this project or engineering technician with 5 years experience supervising electrical features of work in the field with a construction company.
Structural	Licensed Structural Engineer with 2 years experience in the type of work being performed on this project or engineering technician with 5 years experience supervising structural features of work in the field with a construction company.
Architectural	Registered or licensed Architect with 2 years experience in the type of work being performed on this project or technician with 5 years experience supervising architectural features of work in the field with a construction company.
Environmental	Licensed Environmental Engineer with 3 years experience in the type of work being performed on this project.
Submittals	Submittal Clerk with one year of experience.
Concrete, Soils, and Pavements	Material Technician with 2 years experience in the appropriate area

3.4.4 Additional Requirement

In addition to the above experience and education requirements the CQC System Manager must have completed the course entitled "Construction Quality Management for Contractors". If not previously certified and on record at Quality Assurance Branch of Far East District, they must complete the training and receive the certification within 60 days of NTP. This course is periodically offered by Construction Division.

3.4.5 Organizational Changes

Maintain the QC staff at full strength at all times. When it is necessary to make changes to the CQC staff, revise the CQC Plan to reflect the changes and submit the changes to the Contracting Officer for acceptance.

3.5 SUBMITTALS AND DELIVERABLES

Submittals, if needed, must comply with the requirements in Section 01 33 00 SUBMITTAL PROCEDURES. The CQC organization is responsible for certifying that all submittals and deliverables are in compliance with the contract requirements.

3.6 CONTROL

Quality Control is the means by which the Contractor ensures that the construction, to include that of subcontractors and suppliers, complies with the requirements of the contract. At least three phases of control must be conducted by the CQC System Manager for each definable feature of the construction work as follows:

3.6.1 Preparatory Phase

This phase is performed prior to beginning work on each definable feature of work, after all required plans/documents/materials are approved/accepted, and after copies are at the work site. This phase includes:

a. A review of each paragraph of applicable specifications, reference codes, and standards. Make available during the preparatory inspection a copy of those sections of referenced codes and standards applicable to that portion of the work to be accomplished in the field. Maintain and make available in the field for use by Government personnel until final acceptance of the work.

b. Review of the contract drawings.

c. Check to assure that all materials and/or equipment have been tested, submitted, and approved.

d. Review of provisions that have been made to provide required control inspection and testing.

e. Examination of the work area to assure that all required preliminary work has been completed and is in compliance with the contract.

f. Examination of required materials, equipment, and sample work to assure that they are on hand, conform to approved shop drawings or submitted data, and are properly stored.

g. Review of the appropriate activity hazard analysis to assure safety requirements are met.

h. Discussion of procedures for controlling quality of the work including repetitive deficiencies. Document construction tolerances and workmanship standards for that feature of work.

i. Check to ensure that the portion of the plan for the work to be performed has been accepted by the Contracting Officer.

j. Discussion of the initial control phase.

k. The Government must be notified at least 48 hours in advance of beginning the preparatory control phase. Include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. Document the results of the preparatory phase actions by separate minutes prepared by the CQC System Manager and attach to the daily CQC report. Instruct applicable workers as to the acceptable level of workmanship required in order to meet contract specifications.

3.6.2 Initial Phase

This phase is accomplished at the beginning of a definable feature of work. Accomplish the following:

a. Check work to ensure that it is in full compliance with contract requirements. Review minutes of the preparatory meeting.

b. Verify adequacy of controls to ensure full contract compliance. Verify required control inspection and testing.

c. Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Compare with required sample panels as appropriate.

d. Resolve all differences.

e. Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.

f. The Government must be notified at least 48 hours in advance of beginning the initial phase. Prepare separate minutes of this phase by the CQC System Manager and attach to the daily CQC report. Indicate the exact location of initial phase for future reference and comparison with follow-up phases.

g. The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.

3.6.3 Follow-up Phase

Perform daily checks to assure control activities, including control testing, are providing continued compliance with contract requirements, until completion of the particular feature of work. Record the checks in the CQC documentation. Conduct final follow-up checks and correct all deficiencies prior to the start of additional features of work which may be affected by the deficient work. Do not build upon nor conceal non-conforming work.

3.6.4 Additional Preparatory and Initial Phases

Conduct additional preparatory and initial phases on the same definable features of work if: the quality of on-going work is unacceptable; if there are changes in the applicable CQC staff, onsite production supervision or work crew; if work on a definable feature is resumed after a substantial period of inactivity; or if other problems develop.

3.7 TESTS

3.7.1 Testing Procedure

Perform specified or required tests to verify that control measures are adequate to provide a product which conforms to contract requirements. Upon request, furnish to the Government duplicate samples of test specimens for possible testing by the Government. Testing includes operation and/or acceptance tests when specified. Procure the services of a Corps of Engineers approved testing laboratory or establish an approved testing laboratory at the project site. Perform the following activities and record and provide the following data:

a. Verify that testing procedures comply with contract requirements.

b. Verify that facilities and testing equipment are available and comply with testing standards.

c. Check test instrument calibration data against certified standards.

d. Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.

e. Record results of all tests taken, both passing and failing on the CQC report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test. If approved by the Contracting Officer, actual test reports may be submitted later with a reference to the test number and date taken. Provide an information copy of tests performed by an offsite or commercial test facility directly to the Contracting Officer. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this contract.

3.7.2 Testing Laboratories

3.7.2.1 Capability Check

The Government reserves the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques. Laboratories utilized for testing soils, concrete, asphalt, and steel must meet criteria detailed in ASTM D 3740 and ASTM E 329.

3.7.2.2 Capability Recheck

If the selected laboratory fails the capability check, the Contractor will be assessed a charge of $2,000.00 to reimburse the Government for each succeeding recheck of the laboratory or the checking of a subsequently selected laboratory. Such costs will be deducted from the contract amount due the Contractor.

3.7.3 Onsite Laboratory

The Government reserves the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests, and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Government.

3.8 COMPLETION INSPECTION

3.8.1 Punch-Out Inspection

Conduct an inspection of the work by the CQC Manager near the end of the work, or any increment of the work established by a time stated in the SPECIAL CONTRACT REQUIREMENTS Clause, "Commencement, Prosecution, and Completion of Work", or by the specifications. Prepare and include in the CQC documentation a punch list of items which do not conform to the approved drawings and specifications, as required by paragraph DOCUMENTATION. Include within the list of deficiencies the estimated date by which the deficiencies will be corrected. Make a second inspection the CQC System Manager or staff to ascertain that all deficiencies have been corrected. Once this is accomplished, notify the Government that the facility is ready for the Government Pre-Final inspection.

3.8.2 Pre-Final Inspection

The Government will perform the pre-final inspection to verify that the facility is complete and ready to be occupied. A Government Pre-Final Punch List may be developed as a result of this inspection. Ensure that all items on this list have been corrected before notifying the Government, so that a Final inspection with the customer can be scheduled. Correct any items noted on the Pre-Final inspection in a timely manner. These inspections and any deficiency corrections required by this paragraph must be accomplished within the time slated for completion of the entire work or any particular increment of the work if the project is divided into increments by separate completion dates.

3.8.3 Final Acceptance Inspection

The Contractor's Quality Control Inspection personnel, plus the superintendent or other primary management person, and the Contracting Officer's Representative must be in attendance at the final acceptance inspection. Additional Government personnel including, but not limited to, those from Base/Post Civil Facility Engineer user groups, and major commands may also be in attendance. The final acceptance inspection will be formally scheduled by the Contracting Officer based upon results of the Pre-Final inspection. Notify the Contracting Officer at least 14 days prior to the final acceptance inspection and include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection. Failure of the Contractor to have all contract work acceptably complete for this inspection will be cause for the Contracting Officer to bill the Contractor for the Government's additional inspection cost in accordance with the contract clause titled "Inspection of Construction".

3.9 DOCUMENTATION

Maintain current records providing factual evidence that required quality control activities and/or tests have been performed. Include in these records the work of subcontractors and suppliers on an acceptable form that includes, as a minimum, the following information:

a. Contractor/subcontractor and their area of responsibility.

b. Operating plant/equipment with hours worked, idle, or down for repair.

c. Work performed each day, giving location, description, and by whom. When Network Analysis (NAS) is used, identify each phase of work performed each day by NAS activity number.

d. Test and/or control activities performed with results and references to specifications/drawings requirements. Identify the control phase (Preparatory, Initial, Follow-up). List of deficiencies noted, along with corrective action.

e. Quantity of materials received at the site with statement as to acceptability, storage, and reference to specifications/drawings requirements.

f. Submittals and deliverables reviewed, with contract reference, by whom, and action taken.

g. Offsite surveillance activities, including actions taken.

h. Job safety evaluations stating what was checked, results, and instructions or corrective actions.

i. Instructions given/received and conflicts in plans and/or specifications.

k. Contractor's verification statement.

Indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. Cover both conforming and deficient features and include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. Furnish the original and one copy of these records in report form to the Government daily within 24 hours after the date covered by the report, except that reports need not be submitted for days on which no work is performed. As a minimum, prepare and submit one report for every 7 days of no work and on the last day of a no work period. All calendar days must be accounted for throughout the life of the contract. The first report following a day of no work will be for that day only. Reports must be signed and dated by the CQC System Manager. Include copies of test reports and copies of reports prepared by all subordinate quality control personnel within the CQC System Manager Report.

3.10 NOTIFICATION OF NONCOMPLIANCE

The Contracting Officer will notify the Contractor of any detected noncompliance with the foregoing requirements. Take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, will be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders will be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

-- End of Section --

SECTION 01 50 00

TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS
08/09

PART 1 GENERAL

1.1 SUMMARY

Requirements of this Section apply to, and are a component of, each section of the specifications.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C511	(2007) Standard for Reduced-Pressure Principle Backflow Prevention Assembly

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies
FCCCHR Manual	(1988e9) Manual of Cross-Connection Control

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 241	(2009) Standard for Safeguarding Construction, Alteration, and Demolition Operations
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 70/7460-1	(2007; Rev K) Obstruction Marking and Lighting

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009) Manual of Uniform Traffic Control Devices

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office

that will review the submittal for the Government. Submitted the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Construction site plan; G
Traffic control plan; G
Temporary Power Services Diagram

SD-06 Test Reports

Backflow Preventer Tests; G

SD-07 Certificates

Backflow Prevention Training Certificate; G
Backflow Preventers Certificate of Full Approval

1.4 CONSTRUCTION SITE PLAN

Prior to the start of work and within 15 days of Notice to Proceed, Contractor shall submit a site plan showing the locations and dimensions of temporary facilities (including layouts and details, equipment and material storage area (onsite and offsite), and access and haul routes, avenues of ingress/egress to the fenced area and details of the fence installation. Identify any areas which may have to be graveled to prevent the tracking of mud. Indicate if the use of a supplemental or other staging area is desired. Show locations of safety and construction fences, site trailers, construction entrances, trash dumpsters, temporary sanitary facilities, and worker parking areas.

1.4.1 Fencing

Provide fencing along the construction site at all open excavations and tunnels to control access by unauthorized people. Fencing must be installed to be able to restrain a force of at least 114.00 kg (250 pounds) against it.

1.4.2 Temporary Wiring

Provide temporary wiring in accordance with NFPA 241 and NFPA 70, Article 305-6(b), Assured Equipment Grounding Conductor Program. Include frequent inspection of all equipment and apparatus.

1.5 BACKFLOW PREVENTERS

Reduced pressure principle type conforming to the applicable requirements AWWA C511. Provide backflow preventers complete with 65 kg(150 pound) flanged, bronze or brass mounted gate valve and strainer, 304 stainless steel or bronze, internal parts. The particular make, model/design, and size of backflow preventers to be installed must be included in the latest edition of the List of Approved Backflow Prevention Assemblies issued by the FCCCHR List and be accompanied by a Certificate of Full Approval from FCCCHR List. After installation conduct Backflow Preventer Tests and provide test reports verifying that the installation meets the FCCCHR ManualStandards.

1.5.1 BACKFLOW PREVENTERS CERTIFICATE

Certificate of Full Approval from FCCCHR List, University of Southern California, attesting that the design, size and make of each backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. Certificate of Provisional Approval will not be acceptable.

1.5.2 Backflow Prevention Training Certificate

Submit a certificate recognized by the local authority that states the Contractor has completed at least 10 hours of training in backflow preventer installations. The certificate must be current.

PART 2 PRODUCTS

2.1 TEMPORARY SIGNAGE

2.1.1 Bulletin Board

Immediately upon beginning of work, provide a weatherproof glass-covered bulletin board not less than 915 by 1220 mm (36 by 48 inches) in size for displaying the Equal Employment Opportunity poster, a copy of the wage decision contained in the contract, Wage Rate Information poster, and other information approved by the Contracting Officer. Locate the bulletin board at the project site in a conspicuous place easily accessible to all employees, as approved by the Contracting Officer.

2.1.2 Project and Safety Signs

The requirements for the signs, their content, and location are as specified in Section 01 58 00 PROJECT IDENTIFICATION. Erect signs within 15 days after receipt of the notice to proceed. Correct the data required by the safety sign daily, with light colored metallic or non-metallic numerals.

2.2 TEMPORARY TRAFFIC CONTROL

2.2.1 Haul Roads

At contractor's expense construct access and haul roads necessary for proper prosecution of the work under this contract. Construct with suitable grades and widths; sharp curves, blind corners, and dangerous cross traffic are to be avoided. Provide necessary lighting, signs, barricades, and distinctive markings for the safe movement of traffic. The method of dust control, although optional, must be adequate to ensure safe operation at all times. Location, grade, width, and alignment of construction and hauling roads are subject to approval by the Contracting Officer. Lighting must be adequate to assure full and clear visibility for full width of haul road and work areas during any night work operations.

2.2.2 Barricades

Erect and maintain temporary barricades to limit public access to hazardous areas. Whenever safe public access to paved areas such as roads, parking areas or sidewalks is prevented by construction activities or as otherwise necessary to ensure the safety of both pedestrian and vehicular traffic barricades will be required. Securely place barricades clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

PART 3 EXECUTION

3.1 EMPLOYEE PARKING

Contractor employees will park privately owned vehicles in an area designated by the Contracting Officer. This area will be within reasonable walking distance of the construction site. Contractor employee parking must not interfere with existing and established parking requirements of the government installation.

3.2 Identification of Employees

The Contractor shall be responsible for furnishing to each employee, and for requiring each employee engaged on the work to display, identification as approved and directed by the Contracting Officer. Prescribed identification shall immediately be delivered to the Contracting Officer for cancellation upon release of any employee. When required, the Contractor shall obtain and provide fingerprints of persons employed on the project. Contractor and subcontractor personnel shall wear identifying markings on hard hats clearly identifying the company for whom the employee works.

3.3 AVAILABILITY AND USE OF UTILITY SERVICES

3.3.1 Temporary Utilities

Provide temporary utilities required for construction. Materials may be new or used, must be adequate for the required usage, not create unsafe conditions, and not violate applicable codes and standards.

3.3.2 Utility Services

a. The Government will make all reasonably required utilities available to the Contractor from existing outlets and supplies, as specified in the contract. Unless otherwise provided in the contract, the amount of each utility service consumed will not be charged to the Contractor. Carefully conserve any utilities furnished without charge.

b. Reasonable amounts of the available utilities will be made available to the Contractor without charge.

c. The point at which the Government will deliver such utilities or services and the quantity available will be indicated prior to the commencement of construction. Pay all costs incurred in connecting, converting, and transferring the utilities to the work. Make connections, including providing backflow-preventing devices on connections to domestic water lines; provide meters; provide transformers; and make disconnections.

3.3.3 Meters and Temporary Connections

At the Contractors expense and in a manner satisfactory to the Contracting Officer, provide and maintain necessary temporary connections, distribution lines, meter bases, and meters required to measure the amount of each utility used for the purpose of determining excessive utility usage. Notify the Contracting Officer, in writing, 5 working days before final electrical connection is desired. The Contractor shall make the final hot connection after approval of the Contractor's temporary wiring installation and under the supervision of the Government.

3.3.4 Electricity

Subject to available supply, electric power will be made available by the Government, without charge, to the Contractor for performing work at the work area. The Contractor shall carefully conserve electricity furnished. The Contractor, as required and at its own expense and in a workmanlike manner satisfactory to the Contracting Officer, shall extend the existing electrical distribution system (overhead and underground) for temporary electrical service to the worksite, shall install and maintain necessary temporary connections, and shall remove the same prior to final acceptance of the construction. Submit Temporary Power Services Diagram for approval by contracting officer. Diagram shall include, but not be limited to, main disconnect, grounding, service drops, service entrance conductors, feeders, GFCI(s), and all site trailer connections.

3.3.4.1 Temporary Power and Lighting

The Contractor shall provide construction power facilities in accordance with the safety requirements of the National Electric Code NFPA No. 70 and the SAFETY AND HEALTH REQUIREMENTS MANUAL EM 385-1-1. The Contractor, or its delegated subcontractor, shall enforce the safety requirements of electrical extensions for the work of subcontractors. Work shall be accomplished by journeyman electricians.

3.3.4.2 Construction Equipment

In addition to the requirements of SAFETY AND HEALTH REQUIREMENTS MANUAL, EM 385-1-1, temporary wiring conductors installed for operation of construction tools and equipment shall be either Type TW or THW contained in metal raceways, or shall be hard usage or extra hard usage multiconductor cord. Temporary wiring shall be secured above the ground or floor in a workmanlike manner and shall not present an obstacle to persons or equipment. Open wiring may only be used outside of buildings, and then only in accordance with the provisions of the National Electric Code.

3.3.5 Water

Subject to available supply the Government will make available to Contractor, from existing outlets and supplies, reasonable amounts of potable water without charge. Contractor shall reasonably conserve potable water furnished. Contractor, at its own expense, shall install and maintain necessary temporary connections and distribution lines and shall remove the connections and lines prior to final acceptance of construction.

3.3.6 Sanitation

Provide and maintain within the construction area minimum field-type sanitary facilities approved by the Contracting Officer and periodically empty wastes into a municipal, district, or station sanitary sewage system, or remove waste to a commercial facility. Obtain approval from the system owner prior to discharge into any municipal, district, or commercial sanitary sewer system. Any penalties and / or fines associated with improper discharge will be the responsibility of the Contractor. Coordinate with the Contracting Officer and follow station regulations and procedures when discharging into the station sanitary sewer system. Maintain these conveniences at all times without nuisance. Include provisions for pest control and elimination of odors. Government toilet facilities will not be available to Contractor's personnel.

3.3.7 Telephone and Data

Make arrangements and pay all costs for telephone and data connections and facilities desired.

3.4 TRAFFIC PROVISIONS

3.4.1 Maintenance of Traffic

a. Conduct operations in a manner that will not close any thoroughfare or interfere in any way with traffic on railways or highways except with written permission of the Contracting Officer at least 15 calendar days prior to the proposed date for commencement of street or road work, and provide a Traffic Control Plan detailing the proposed controls to traffic movement for approval. The plan must be in accordance with local regulations and the MUTCD, Part VI and shall indicate scheduling, placement, and maintenance of traffic control devices in accordance with the U.S. Department of Transportation, Federal Highway Administration publication, Manual on Uniform Traffic Control Devices. The Contractor shall identify by site inspection and indicate on the plan all roads and trails used by military or civilian vehicular traffic and, by traffic control devices, prevent this traffic from entering the construction zone. Contractor may move oversized and slow-moving vehicles to the worksite provided requirements of the highway authority have been met.

b. The Contractor shall provide for movement of traffic through and around the construction zone in a manner that is conducive to the safety of motorists, pedestrians, and workers. This shall include placement and maintenance of traffic control devices in accordance with the U.S. Department of Transportation, Federal Highway Administration publication, Manual on Uniform Traffic Control Devices. Streets (except dead end) may be closed to traffic temporarily by approved written request to the Contracting Officer at least 10 working days prior to street closure. Street closures shall at all times allow street access to a building from one direction. Excavations shall not remain open for more than 1 working day without approval.

c. Conduct work so as to minimize obstruction of traffic, and maintain traffic on at least half of the roadway width at all times. Obtain approval from the Contracting Officer prior to starting any activity that will obstruct traffic.

d. Provide, erect, and maintain, at contractor's expense, lights, barriers, signals, passageways, detours, overhead protection, Life Safety Signage, and other items that may be required by the authority having jurisdiction.

3.4.2 Protection of Traffic

Maintain and protect traffic on all affected roads during the construction period except as otherwise specifically directed by the Contracting Officer. Measures for the protection and diversion of traffic, including the provision of watchmen and flag men, erection of barricades, placing of lights around and in front of equipment the work, and the erection and maintenance of adequate warning, danger, and direction signs, will be as required by the State and local authorities having jurisdiction. Protect the traveling public from damage to person and property. Minimize the interference with public traffic on roads selected for hauling material to and from the site. Investigate the adequacy of existing roads and their allowable load limit. Contractor is responsible for the repair of any damage to roads caused by construction operations.

3.4.3 Rush Hour Restrictions

Do not interfere with the peak traffic flows preceding and during normal operations without notification to and approval by the Contracting Officer.

3.4.4 Dust Control

Dust control methods and procedures must be approved by the Contracting Officer. Treat dust abatement on access roads with applications of calcium chloride, water sprinklers, or similar methods or treatment.

3.5 PLANNED UTILITY OUTAGES

Apply for utility outages at least 30 days in advance. As a minimum, the request should include the location of the outage, utilities and buildings or areas affected, duration of outage, and any necessary sketches. Once approved, and at least one week prior to the scheduled utility outage, Contractor shall inform building occupants in writing of the date, time, and expected duration of the outage and shall note the name of persons who were informed about the outage and the date and time occupants were informed. For area outages involving more than five buildings, Contractor will be allowed to post signs along all access roads into the area. Sign material and letter sizes shall be as discussed in Section 01 58 00, PROJECT IDENTIFICATION and indicate utilities and buildings or areas affected, date, time, duration of outage, and include name and phone number of Contracting Officer Representative. Contractor shall notify Contracting Officer Representative when preparations for outage are completed.

3.6 CONTRACTOR'S TEMPORARY FACILITIES

Contractor-owned or -leased trailers must be identified by Government assigned numbers. Size and location of the number will comply with approved temporary site permit. Apply the number to the trailer within 14 calendar days of notification, or sooner, if directed by the Government.

3.6.1 Safety

Protect the integrity of any installed safety systems or personnel safety devices. If entrance into systems serving safety devices is required, the Contractor must obtain prior approval from the Contracting Officer. If it is temporarily necessary to remove or disable personnel safety devices in order to accomplish contract requirements, provide alternative means of protection prior to removing or disabling any permanently installed safety devices or equipment and obtain approval from the Contracting Officer.

3.6.2 Administrative Field Offices

Provide and maintain administrative field office facilities within the construction area at the designated site. Government office and warehouse facilities will not be available to the Contractor's personnel. Costs for connection to utilities and security of the office shall be at the contractor's expense.

Upon completion of the project remove the bulletin board, signs, barricades, haul roads, and any other temporary products from the site. After removal of trailers, materials, and equipment from within the fenced area, remove the fence that will become the property of the Contractor. Restore to the original or better condition, areas used by the Contractor for the storage of equipment or material, or other use. Gravel used to traverse grassed areas must be removed and the area restored to its original condition, including top soil and seeding as necessary.

3.6.3 Storage Area

Construct a temporary 1.8 m (6 foot) high chain link fence around trailers and materials. Include plastic strip inserts, colored green or brown, so that visibility through the fence is obstructed. Fence posts may be driven, in lieu of concrete bases, where soil conditions permit. Do not place or store Trailers, materials, or equipment outside the fenced area unless such trailers, materials, or equipment are assigned a separate and distinct storage area by the Contracting Officer away from the vicinity of the construction site but within the installation boundaries. Trailers, equipment, or materials must not be open to public view with the exception of those items which are in support of ongoing work on any given day. Do not stockpile materials outside the fence in preparation for the next day's work. Park mobile equipment, such as tractors, wheeled lifting equipment, cranes, trucks, and like equipment within the fenced area at the end of each work day.

3.6.4 Supplemental Storage Area

Upon Contractor's request, the Contracting Officer will designate another or supplemental area for the Contractor's use and storage of trailers, equipment, and materials, subject to availability of space. This area may or may not be in close proximity to the construction site but will be within the installation boundaries. Fencing of materials or equipment will be required at this site and the Contractor is responsible for cleanliness and orderliness of the area used and for the security of any material or equipment stored in this area. Utilities will not be provided to this area by the Government.

3.6.5 Appearance of Trailers

a. Trailers utilized by the Contractor for administrative or material storage purposes must present a clean and neat exterior appearance and be in a state of good repair. Trailers which, in the opinion of the Contracting Officer, require exterior painting or maintenance will not be allowed on installation property.

b. Paint using suitable paint and maintain the temporary facilities. Failure to do so will be sufficient reason to require their removal.

3.6.6 Maintenance of Storage Areas

Keep fencing in a state of good repair and proper alignment. Grassed or unpaved areas, which are not established roadways, will be covered with a layer of gravel as necessary to prevent rutting and the tracking of mud onto paved or established roadways, should the Contractor elect to traverse them with construction equipment or other vehicles; gravel gradation will be at the Contractor's discretion. Mow and maintain grass located within the boundaries of the construction site for the duration of the project. Grass and vegetation along fences, buildings, under trailers, and in areas not accessible to mowers will be edged or trimmed neatly.

3.6.7 New Building

In the event a new building is constructed for the temporary project field office, it will be a minimum 3.6 m (12 feet) in width, 5 m (16 feet) in length and have a minimum of 2.1 m (7 feet) headroom. Equip the building with approved electrical wiring, at least one double convenience outlet and the required switches and fuses to provide 110-120 volt power. Provide a work table with stool, desk with chair, two additional chairs, and one legal size file cabinet that can be locked. The building must be waterproof, supplied with a heater, have a minimum of two doors, electric lights, a telephone, a battery operated smoke detector alarm, a sufficient number of adjustable windows for adequate light and ventilation, and a supply of approved drinking water. Approved sanitary facilities must be furnished. Screen the windows and doors and provide the doors with dead bolt type locking devices or a padlock and heavy duty hasp bolted to the door. Door hinge pins will be non-removable. Arrange the windows to open and to be securely fastened from the inside. Protect glass panels in windows by bars or heavy mesh screens to prevent easy access. In warm weather, furnish air conditioning capable of maintaining the office at 50 percent relative humidity and a room temperature 11 degrees C (20 degrees F) below the outside temperature when the outside temperature is 35 degrees C (95 degrees F). Any new building erected for a temporary field office must be maintained by the Contractor during the life of the contract and upon completion and acceptance of the work become the property of the Contractor and removed from the site. All charges for telephone service for the temporary field office will be borne by the Contractor, including long distance charges up to a maximum of $75.00 per month.

3.6.8 Security Provisions

Provide adequate outside security lighting at the Contractor's temporary facilities. The Contractor will be responsible for the security of its own equipment; in addition, the Contractor will notify the appropriate law enforcement agency requesting periodic security checks of the temporary project field office.

3.6.9 Plant Communications

Whenever the Contractor has the individual elements of its plant so located that operation by normal voice between these elements is not satisfactory, the Contractor shall install a satisfactory means of communication, such as telephone or other suitable devices. The devices shall be made available for use by Government personnel.

3.6.10 Weather Protection of Temporary Facilities and Stored Materials

Take necessary precautions to ensure that roof openings and other critical openings in the building are monitored carefully. Take immediate actions required to seal off such openings when rain or other detrimental weather is imminent, and at the end of each workday. Ensure that the openings are completely sealed off to protect materials and equipment in the building from damage.

3.6.10.1 Building and Site Storm Protection

When a warning of gale force winds is issued, take precautions to minimize danger to persons, and protect the work and nearby Government property. Precautions must include, but are not limited to, closing openings; removing loose materials, tools and equipment from exposed locations; and removing or securing scaffolding and other temporary work. Close openings in the work when storms of lesser intensity pose a threat to the work or any nearby Government property.

3.6.10.2 Typhoon Condition of Readiness

Unless directed otherwise, comply with:

a. Condition FOUR (Sustained winds of 93 km/hr (50 knots) or greater expected within 72 hours): Normal daily jobsite cleanup and good housekeeping practices. Collect and store in piles or containers scrap lumber, waste material, and rubbish for removal and disposal at the close of each work day. Maintain the construction site including storage areas, free of accumulation of debris. Stack form lumber in neat piles less than one m 94 feet) high. Remove all debris, trash, or objects that could become missile hazards.

b. Condition THREE (Sustained winds of 93 km/hr (50 knots) or greater expected within 48 hours): Maintain "Condition FOUR" requirements and commence securing operations necessary for "Condition ONE" which cannot be completed within 18 hours. Cease all routine activities which might interfere with securing operations. Commence securing and stow all gear and portable equipment. Make preparations for securing buildings. Review requirements pertaining to "Condition TWO" and continue action as necessary to attain "Condition THREE" readiness. Contact Contracting Officer for weather and COR updates and completion of required actions.

c. Condition TWO (Sustained winds of 93 km/hr (50 knots) or greater expected within 24 hours): Curtail or cease routine activities until securing operation is complete. Reinforce or remove form work and scaffolding. Secure machinery, tools, equipment, materials, or remove from the jobsite. Expend every effort to clear all missile hazards and loose equipment from general base areas. Contact Contracting Officer for weather and Condition of Readiness (COR) updates and completion of required actions.

d. Condition ONE. (Sustained winds of 93 km/hr (50 knots) or greater expected within 12 hours): Secure the jobsite, and leave Government premises.

3.6.11 Restoration of Storage Area

Upon completion of the project remove the bulletin board, signs, barricades, haul roads, and any other temporary products from the site. After removal of trailers, materials, and equipment from within the fenced area, remove the fence that will become the property of the Contractor. Restore to the original or better condition, areas used by the Contractor for the storage of equipment or material, or other use. Gravel used to traverse grassed areas must be removed and the area restored to its original condition, including top soil and seeding as necessary.

3.7 TEMPORARY PROJECT SAFETY FENCING

As soon as practicable, but not later than 15 days after the date established for commencement of work, furnish and erect temporary project safety fencing at the work site. The safety fencing must be a high visibility orange colored, high density polyethylene grid or approved equal, a minimum of 1.1 m (42 inches) high, supported and tightly secured to steel posts located on maximum 3 m (10 foot) centers, constructed at the approved location. Maintain the safety fencing during the life of the contract and, upon completion and acceptance of the work, will become the property of the Contractor and be removed from the work site.

3.8 Obstruction Lighting of Cranes

Provide a minimum of 2 aviation red or high intensity white obstruction lights on temporary structures (including cranes) over 30 meter (100 feet) above ground level. Light construction and installation must comply with FAA AC 70/7460-1. Lights must be operational during periods of reduced visibility, darkness, and as directed by the Contracting Officer.

3.9 Fire Protection

Provide temporary fire protection equipment for the protection of personnel and property during construction. Remove debris and flammable materials daily to minimize potential hazards.

3.10 CLEANUP

Remove construction debris, waste materials, packaging material and the like from the work site daily. Any dirt or mud which is tracked onto paved or surfaced roadways must be cleaned away. Store within the fenced area described above or at the supplemental storage area any materials resulting from demolition activities which are salvageable. Neatly stacked stored materials not in trailers, whether new or salvaged.

-- End of Section --

SECTION 01 57 20.00 10

ENVIRONMENTAL PROTECTION
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. ARMY (DA)

DA AR 200-1	(2007) Environmental Protection and Enhancement

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 260	Hazardous Waste Management System: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 279	Standards for the Management of Used Oil
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 355	Emergency Planning and Notification
40 CFR 68	Chemical Accident Prevention Provisions
49 CFR 171 - 178	Hazardous Materials Regulations

REPUBLIC OF KOREA (ROK) LAW

Act No. 10893	(21 JUL 2011) Korean Atmospheric Environment Conservation Act (AECA)
Act No. 10911	(25 JUL 2011) Korean Waste Management Act (WMA)
PD No. 22601	(31 DEC 2010) Korean Presidential Decree (PD) of AECA
PD No. 22889	(6 APR 2011) Korean Presidential Decree

	(PD) of WMA
MD No. 418	(19 Aug 2011) Korean Ministry of Environment, Ministerial Decree (MD) of AECA
MD No. 406	(31 MAR 2011) Korean Ministry of Environment, Ministerial Decree (MD) of WMA

U.S. FORCES KOREA (USFK)

USFK PAM 200-1	(2005) Environmental Governing Standards

1.2 DEFINITIONS

1.2.1 Environmental Pollution and Damage

Environmental pollution and damage is the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade the environment aesthetically, culturally and/or historically.

1.2.2 Environmental Protection

Environmental protection is the prevention/control of pollution and habitat disruption that may occur to the environment during construction. The control of environmental pollution and damage requires consideration of land, water, and air; biological and cultural resources; and includes management of visual aesthetics; noise; solid, chemical, gaseous, and liquid waste; radiant energy and radioactive material as well as other pollutants.

1.2.3 Contractor Generated Hazardous Waste

Contractor generated hazardous waste means materials that, if abandoned or disposed of, may meet the definition of a hazardous waste. These waste streams would typically consist of material brought on site by the Contractor to execute work, but are not fully consumed during the course of construction. Examples include, but are not limited to, excess paint thinners (i.e. methyl ethyl ketone, toluene etc.), waste thinners, excess paints, excess solvents, waste solvents, and excess pesticides, and contaminated pesticide equipment rinse water.

1.2.4 Installation Pest Management Coordinator

Installation Pest Management Coordinator (IPMC) is the individual officially designated by the Installation Commander to oversee the Installation Pest Management Program and the Installation Pest Management Plan.

1.2.5 Land Application for Discharge Water

The term "Land Application" for discharge water implies that the Contractor must discharge water at a rate which allows the water to percolate into the soil. No sheeting action, soil erosion, discharge into storm sewers, discharge into defined drainage areas must occur. Land Application must be in compliance with all applicable National, Provincial, and Local laws and regulations.

1.2.6 Pesticide

Pesticide is defined as any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, or intended for use as a plant regulator, defoliant or desiccant.

1.2.7 Pests

The term "pests" means arthropods, birds, rodents, nematodes, fungi, bacteria, viruses, algae, snails, marine borers, snakes, weeds and other organisms (except for human or animal disease-causing organisms) that adversely affect readiness, military operations, or the well-being of personnel and animals; attack or damage real property, supplies, equipment, or vegetation; or are otherwise undesirable.

1.2.8 Surface Discharge

The term "Surface Discharge" implies that the water is discharged with possible sheeting action and subsequent soil erosion may occur. Waters that are surface discharged may terminate in drainage ditches, storm sewers, creeks and would require a permit to discharge water from the governing agency.

1.3 GENERAL REQUIREMENTS

Minimize environmental pollution and damage that may occur as the result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work must be protected during the entire duration of this contract. Comply with all applicable environmental USFK, ROK, and Local laws, regulations and US military installation policies and guidance related with the environment and protection of resources. Any delays resulting from failure to comply with environmental laws and regulations will be the Contractor's responsibility.

1.4 SUBCONTRACTORS

Ensure compliance with this section by subcontractors.

1.5 PAYMENT

No separate payment will be made for work covered under this section. Payment of fees associated with environmental permits, application, and/or notices obtained by the Contractor, and payment of all fines/fees for violation or non-compliance with USFK, National, Provincial, and/or Local laws and regulations are the Contractor's responsibility. All costs associated with this section must be included in the contract price.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Environmental Protection Plan; G

1.7 ENVIRONMENTAL PROTECTION PLAN

Prior to commencing construction activities or delivery of materials to the site, submit an Environmental Protection Plan for review and approval by the Contracting Officer. The purpose of the Environmental Protection Plan is to present a comprehensive overview of known or potential environmental issues which the Contractor must address during construction. Issues of concern must be defined within the Environmental Protection Plan as outlined in this section. Address each topic at a level of detail commensurate with the environmental issue and required construction task(s). Topics or issues which are not identified in this section, but are considered necessary, must be identified and discussed after those items formally identified in this section. Prior to submittal of the Environmental Protection Plan, meet with the Contracting Officer for the purpose of discussing the implementation of the initial Environmental Protection Plan; possible subsequent additions and revisions to the plan including any reporting requirements; and methods for administration of the Contractor's Environmental Plans. The Environmental Protection Plan must be current and maintained onsite by the Contractor.

1.7.1 Compliance

No requirement in this Section will relieve the Contractor of any applicable USFK, National, Provincial, and/or Local environmental protection laws and regulations. During Construction, the Contractor will be responsible for identifying, implementing, and submitting for approval any additional requirements to be included in the Environmental Protection Plan.

1.7.2 Contents

Include in the environmental protection plan, but not limit it to, the following:

a. A List of USFK and ROK National, Provincial, and/or Local laws, regulations and permits concerning environmental protection, pollution control and abatement that are applicable to the Contractor's proposed operations and the requirements imposed by those laws, regulations, and permits.

b. Name(s) of person(s) within the Contractor's organization who is(are) responsible for ensuring adherence to the Environmental Protection Plan.

c. Name(s) and qualifications of person(s) responsible for manifesting hazardous waste to be removed from the site, if applicable.

d. Name(s) and qualifications of person(s) responsible for training the Contractor's environmental protection personnel and a description of the Contractor's environmental protection personnel training program.

e. An erosion and sediment control plan which identifies the type and location of the erosion and sediment controls to be provided. The plan must include monitoring and reporting requirements to assure that the control measures are in compliance with the erosion and sediment control plan, USFK, National, Provincial, and/or Local laws and regulations. A Storm Water Pollution Prevention Plan (SWPPP) may be substituted for this plan.

f. Drawings showing locations of proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials on the site.

g. Traffic control plans including measures to reduce erosion of temporary roadbeds by construction traffic, especially during wet weather. Plan shall include measures to minimize the amount of mud transported onto paved public roads by vehicles or runoff.

h. Work area plan showing the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas including methods for protection of features to be preserved within authorized work areas.

i. Drawing showing the location of borrow areas.

j. Include in the Spill Control plan the procedures, instructions, and reports to be used in the event of an unforeseen spill of a substance regulated by 40 CFR 68, 40 CFR 302, 40 CFR 355, and/or regulated under USFK, Provincial, or Local laws and regulations. The Spill Control Plan supplements the requirements of EM 385-1-1. Include in this plan, as a minimum:

   (1) The name of the individual who will report any spills or hazardous substance releases and who will follow up with complete documentation. This individual will immediately notify the Contracting Officer and Facility Environmental Office in addition to the legally required local reporting channels if a reportable quantity is released to the environment. Include in the plan a list of the required reporting channels and telephone numbers.

   (2) The name and qualifications of the individual who will be responsible for implementing and supervising the containment and cleanup.

   (3) Training requirements for Contractor's personnel and methods of accomplishing the training.

   (4) A list of materials and equipment to be immediately available at the job site, tailored to cleanup work of the potential hazard(s) identified.

   (5) The names and locations of suppliers of containment materials and locations of additional fuel oil recovery, cleanup, restoration, and material-placement equipment available in case of an unforeseen spill emergency.

   (6) The methods and procedures to be used for expeditious contaminant cleanup.

k. A non-hazardous solid waste disposal plan identifying methods and locations for solid waste disposal including clearing debris and schedules for disposal.

(1) Identify any subcontractors responsible for the transportation and disposal of solid waste. Submit licenses or permits for solid waste disposal sites that are not a commercial operating facility.

(2) A recycling and solid waste minimization plan with a list of measures to reduce consumption of energy and natural resources. Detail in the plan the Contractor's actions to comply with and to participate in USFK, National, Provincial, and/or Local government sponsored recycling programs to reduce the volume of solid waste at the source.

l. An air pollution control plan detailing provisions to assure that dust, debris, materials, trash, etc., do not become air borne and travel off the project site.

m. A contaminant prevention plan that: identifies potentially hazardous substances to be used on the job site; identifies the intended actions to prevent introduction of such materials into the air, water, or ground; and details provisions for compliance with USFK, National, Provincial, and/or Local laws and regulations for storage and handling of these materials. In accordance with EM 385-1-1, a copy of the Material Safety Data Sheets (MSDS) and the maximum quantity of each hazardous material to be onsite at any given time must be included in the contaminant prevention plan. Update the plan as new hazardous materials are brought onsite or removed from the site.

n. A waste water management plan that identifies the methods and procedures for management and/or discharge of waste waters which are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of ground water, disinfection water, hydrostatic test water, and water used in flushing of lines. If a settling/retention pond is required, the plan must include the design of the pond including drawings, removal plan, and testing requirements for possible pollutants. If land application will be the method of disposal for the waste water, the plan must include a sketch showing the location for land application along with a description of the pretreatment methods to be implemented. If surface discharge will be the method of disposal, include a copy of the permit and associated documents as an attachment prior to discharging the waste water. If disposal is to a sanitary sewer, the plan must include documentation that the Waste Water Treatment Plant Operator has approved the flow rate, volume, and type of discharge.

o. Methods for Protection of Features to be preserved within authorized work areas. The Contractor shall prepare a listing of methods to protect resources needing protection; i.e., trees, shrubs, vines, grasses and ground cover, landscape features, air and water quality and soil.

p. Include and update a pesticide treatment plan, as information becomes available. Include in the plan: sequence of treatment, dates, times, locations, pesticide trade name, EPA registration numbers, authorized uses, chemical composition, formulation, original and applied concentration, application rates of active ingredient (i.e. pounds of active ingredient applied), equipment used for application and calibration of equipment. USFK, National, Provincial, and/or Local pest management record keeping and reporting requirements as well as any additional Installation Project Office specific requirements are the Contractor's responsibility in conformance with DA AR 200-1

Chapter 5--Pest Management, Section 5-4 "Program requirements" for data required to be reported to the Installation.

q. Procedures to be implemented to provide the required environmental protection and to comply with the applicable laws and regulations. The Contractor shall set out the procedures to be followed to correct pollution of the environment due to accident, natural causes, or failure to follow the procedure set out in accordance with the environmental protection plan.

1.7.3 Appendix

Attach to the Environmental Protection Plan, as an appendix, copies of all environmental permits, permit application packages, approvals to construct, notifications, certifications, reports, and termination documents. Contractor shall reference USFK PAM 200-1 for environmental quality, Act No. 10893, PD No. 22601 and MD No. 418 for AECA related work.

1.8 PROTECTION FEATURES

This paragraph supplements the Contract Clause PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES, AND IMPROVEMENTS. Prior to start of any onsite construction activities, the Contractor and the Contracting Officer will make a joint condition survey. Immediately following the survey, the Contractor will prepare a brief report including a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the Contractor's assigned storage area and access route(s), as applicable. This survey report will be signed by both the Contractor and the Contracting Officer upon mutual agreement as to its accuracy and completeness. The Contractor must protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference which their preservation may cause to the work under the contract.

1.9 ENVIRONMENTAL ASSESSMENT OF CONTRACT DEVIATIONS

Any deviations from the drawings, plans and specifications, requested by the Contractor and which may have an environmental impact, will be subject to approval by the Contracting Officer and may require an extended review, processing, and approval time. The Contracting Officer reserves the right to disapprove alternate methods, even if they are more cost effective, if the Contracting Officer determines that the proposed alternate method will have an adverse environmental impact.

1.10 NOTIFICATION

The Contracting Officer will notify the Contractor in writing of any observed noncompliance with USFK, National, Provincial, and/or Local environmental laws or regulations, permits, and other elements of the Contractor's Environmental Protection plan. After receipt of such notice, the Contractor will inform the Contracting Officer of the proposed corrective action and take such action when approved by the Contracting Officer. The Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions will be granted or equitable adjustments allowed for any such suspensions. This is in addition to any other actions the Contracting

Officer may take under the contract, or in accordance with the Federal Acquisition Regulation or Federal Law.

1.11 ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

The Contractor shall perform work consistent with the relevant policy and objectives identified in the agency - Installation Management Command (IMCOM) Korea and IMCOM Headquarters' organizational or facility environmental management system (EMS) applicable for the contract. The Contractor shall perform work in a manner that conforms to all appropriate Environmental Management Programs and Operational Controls identified by the agency, organizational, or facility EMS, and provide monitoring and measurement information as ordered in a Task Order, to address environmental performance relative to the environmental, energy, and transportation management goals. In the event an environmental nonconformance or noncompliance associated with the contracted services is identified, the Contractor shall take corrective and/or preventative actions. In the case of a noncompliance, the Contractor shall respond and take corrective action immediately based on the time schedule established by the EMS Site Coordinator. The Contractor shall ensure that their employees are aware of the roles and responsibilities identified by IMCOM Korea's environmental management system and how these requirements affect their work performed under the contract.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.1 ENVIRONMENTAL PERMITS AND COMMITMENTS

Obtaining and complying with all environmental permits and commitments required by USFK, National, Provincial, and/or Local environmental laws and regulations is the Contractor's responsibility.

3.2 LAND RESOURCES

Confine all activities to areas defined by the drawings and specifications. Identify any land resources to be preserved within the work area prior to the beginning of any construction. Do not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without approval, except in areas indicated on the drawings or specified to be cleared. Ropes, cables, or guys will not be fastened to or attached to any trees for anchorage unless specifically authorized. Provide effective protection for land and vegetation resources at all times, as defined in the following subparagraphs. Remove stone, soil, or other materials displaced into uncleared areas.

3.2.1 Work Area Limits

Mark the areas that need not be disturbed under this contract prior to commencing construction activities. Mark or fence isolated areas within the general work area which are not to be disturbed. Protect monuments and markers before construction operations commence. Where construction operations are to be conducted during darkness, any markers must be visible in the dark. The Contractor's personnel must be knowledgeable of the purpose for marking and/or protecting particular objects.

3.2.2 Landscape

Trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved must be clearly identified by marking, fencing, or wrapping with boards, or any other approved techniques. Restore landscape features damaged or destroyed during construction operations outside the limits of the approved work area.

3.2.3 Erosion and Sediment Controls

Providing erosion and sediment control measures in accordance with USFK, National, Provincial, and/or Local laws and regulations is the Contractor's responsibility. Select and maintain the erosion and sediment controls such that water quality standards are not violated as a result of construction activities. The area of bare soil exposed at any one time by construction operations should be kept to a minimum. Construct or install temporary and permanent erosion and sediment control best management practices (BMPs). BMPs may include, but not be limited to, vegetation cover, stream bank stabilization, slope stabilization, silt fences, construction of terraces, interceptor channels, sediment traps, inlet and outfall protection, diversion channels, and sedimentation basins. Remove any temporary measures after the area has been stabilized.

3.2.4 Contractor Facilities and Work Areas

Place field offices, staging areas, stockpile storage, and temporary buildings in areas designated on the drawings or as directed by the Contracting Officer. Temporary movement or relocation of Contractor facilities will be made only when approved. Erosion and sediment controls must be provided for onsite borrow and spoil areas to prevent sediment from entering nearby waters. Temporary excavation and embankments for plant and/or work areas must be controlled to protect adjacent areas.

3.3 WATER RESOURCES

Monitor all water areas affected by construction activities to prevent pollution of surface and ground waters. Do not apply toxic or hazardous chemicals to soil or vegetation unless otherwise indicated. For construction activities immediately adjacent to impaired surface waters, the Contractor must be capable of quantifying sediment or pollutant loading to that surface water when required by National, Provincial, or Local laws, and regulations. In particular, toxic or hazardous chemicals shall not be applied to soil or vegetation in a manner that may cause contamination of the fresh water reserves or sources. Toxic or Hazardous Chemicals include, but are not limited to, fuels, oils, bituminous, calcium chloride, and acid.

3.3.1 Cofferdams, Diversions, and Dewatering Operations

The Contractor shall plan his operation and perform all work necessary to minimize adverse impact of violation of the water quality standards as may be designated by Korean governmental authorities. Construction operations for dewatering, and other relocated activities shall be controlled at all times to limit the impact of water turbidity on the habitat for wildlife and impacts on water quality for downstream use and to limit the impact on the safety of the adjacent structures and facilities caused from the ground water level draw down.

3.3.2 Stream Crossings

Stream crossings shall be controlled during construction. Crossings shall provide movement of materials or equipment, which do not violate water pollution control standards of Korean National, Provincial or Local government.

3.3.3 Wetlands

Do not enter, disturb, destroy, or allow discharge of contaminants into any wetlands.

3.3.4 Monitoring of Water Areas

Monitoring of Water Areas Affected by Construction Activities shall be the responsibility of the Contractor. All water areas affected by construction activities shall be monitored by the Contractor.

3.4 AIR RESOURCES

The Contractor shall keep construction activities under surveillance, management and control to minimize pollution of air resources. All activities, equipment, processes, and work operated or performed by the Contractor in accomplishing the specified construction shall be in strict accordance with USFK, National, Provincial, and/or Local rules and regulations. Ambient Air Quality Standards as may be set by Korean governmental authorities shall be maintained for those construction operations and activities specified. Special management techniques as set out below shall be implemented to control air pollution by the construction activities which are included in the contract.

3.4.1 Particulates

Dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials, such as from asphaltic batch plants; must be controlled at all times, including weekends, holidays and hours when work is not in progress. Maintain excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and other work areas within or outside the project boundaries free from particulates which would cause the air pollution standards mentioned in paragraph entitled Air Resources to be exceeded or which would cause a hazard or a nuisance. Sprinkling, chemical treatment of an approved type, baghouse, scrubbers, electrostatic precipitators or other methods will be permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated to keep the disturbed area damp at all times. Provide sufficient, competent equipment available to accomplish these tasks. Perform particulate control as the work proceeds and whenever a particulate nuisance or hazard occurs. Comply with all local visibility regulations.

3.4.2 Odors

Odors from construction activities must be controlled at all times. The odors must be in compliance with local ordinances and may not constitute a health hazard.

3.4.3 Sound Intrusions

Keep construction activities under surveillance and control to minimize environment damage by noise.

3.4.4 Burning

Burning is prohibited on the Government premises.

3.4.5 Hydrocarbons and Carbon Monoxide

Hydrocarbons and Carbon Monoxide emissions from equipment shall be controlled to Korean governmental allowable limits at all times.

3.5 RESTORATION OF LANDSCAPE DAMAGE

Any trees or other landscape feature scarred or damaged by the Contractor’s operations shall be restored as nearly as possible to its original condition at the Contractor’s expense. The Contracting Officer will decide what method of restoration shall be used, and weather damaged trees shall be treated and healed or removed and disposed of. All scars made on trees, designated on the plans to remain, and all cuts for the removal of limbs larger than 25 mm (1 inch) in diameter shall be coated as soon as possible with an approved tree wound dressing. All trimming or pruning shall be performed in an approved manner by experienced workmen with saws or pruning shears. Tree trimming with axes will not be permitted. Where tree climbing is necessary, the use of climbing spurs will not be permitted. Trees that are to remain, either within or outside established clearing limits, that are subsequently damaged by the Contractor and are beyond saving in the opinion of the Contracting Officer, shall be immediately removed and replaced with a nursery-grown tree of the same species. Replacement trees shall measure no less than 50 mm (2 inches) in diameter at 150 mm (6 inches) above the ground level.

3.6 CHEMICAL MATERIALS MANAGEMENT AND WASTE DISPOSAL

The construction waste generated during construction or demolition shall be disposed in compliance with Korean Waste Management Act No. 10911, Korean Presidential Decree of Waste Management Act - PD No. 22889, and Korean Ministry of Environment, Ministerial Decree of Waste Management Act - MD No. 406. Disposal of wastes will be as directed below, unless otherwise specified in other sections and/or shown on the drawings.

3.6.1 Solid Wastes

Place solid wastes (excluding clearing debris) in containers which are emptied on a regular schedule. Handling, storage, and disposal must be conducted to prevent contamination. Employ segregation measures so that no hazardous or toxic waste will become co-mingled with solid waste. Transport solid waste off Government property and dispose of it in compliance with National, Provincial, and/or Local requirements for solid waste disposal. Verify that the selected transporters and disposal facilities have the necessary permits and licenses to operate. Comply with National, Provincial, and/or Local laws and regulations pertaining to the use of landfill areas.

3.6.2 Chemicals and Chemical Wastes

Dispense chemicals ensuring no spillage to the ground or water. Perform and document periodic inspections of dispensing areas to identify leakage and initiate corrective action. This documentation will be periodically reviewed by the Government. Collect chemical waste in corrosion resistant, compatible containers. Collection drums must be monitored and removed to a staging or storage area when contents are within 150 mm (6 inches) of the top. Wastes will be classified, managed, stored, and disposed of in accordance with Korean National, Provincial and local laws, requirements, and regulations.

3.6.3 Contractor Generated Hazardous Wastes/Excess Hazardous Materials

Hazardous wastes are defined in 40 CFR 261, or are as defined by applicable Korean National, Provincial, and Local regulations. Hazardous materials are defined in 49 CFR 171 - 178. At a minimum, manage and store hazardous waste in compliance with 40 CFR 262 and Korean National, Provincial, and local laws, requirements, and regulations. Take sufficient measures to prevent spillage of hazardous and toxic materials during dispensing. Segregate hazardous waste from other materials and wastes, protect it from the weather by placing it in a safe covered location, and take precautionary measures such as berming or other appropriate measures against accidental spillage. Storage, describing, packaging, labeling, marking, and placarding of hazardous waste and hazardous material in accordance with 49 CFR 171 - 178, Korean National, Provincial, and local laws and regulations is the Contractor's responsibility. Transport Contractor generated hazardous waste off Government property within 60 days in accordance with the Environmental Protection Agency and the Department of Transportation laws and regulations. Dispose of hazardous waste in compliance with Korean National, Provincial, and Local laws and regulations. Spills of hazardous or toxic materials must be immediately reported to the Contracting Officer and the Facility Environmental Office. Cleanup and cleanup costs due to spills are the Contractor's responsibility. The disposition of Contractor generated hazardous waste and excess hazardous materials are the Contractor's responsibility unless otherwise specified in the contract, task order, or delivery order.

3.6.4 Fuel and Lubricants

Storage, fueling and lubrication of equipment and motor vehicles must be conducted in a manner that affords the maximum protection against spill and evaporation. Manage and store fuel, lubricants and oil in accordance with all USFK, National, Provincial, and/or Local laws and regulations. Used lubricants and used oil to be discarded must be stored in marked corrosion-resistant containers and recycled or disposed in accordance with 40 CFR 279, USFK, National, Provincial, and/or Local laws and regulations. Storage of fuel on the project site is not allowed. Fuel must be brought to the project site each day that work is performed.

3.6.5 Waste Water

Disposal of waste water will be as specified below.

a. Waste water from construction activities, such as onsite material processing, concrete curing, foundation and concrete clean-up, water used in concrete trucks, forms, etc. will not be allowed to enter water ways or to be discharged prior to being treated to remove pollutants. Dispose of the construction related waste water off-Government property in accordance with all USFK, National, Provincial, and/or Local laws and regulations.

b. For discharge of ground water, the Contractor will land apply on the project site in accordance with all National, Provincial, and/or Local laws and regulations for pumping and land applying ground water.

c. Water generated from the flushing of lines after disinfection or disinfection in conjunction with hydrostatic testing will be land applied in accordance with all National, Provincial and/or Local laws, requirements, and regulations for land application .

3.7 RECYCLING AND WASTE MINIMIZATION

Participate in USFK, National, Provincial, and Local government sponsored recycling programs. The Contractor is further encouraged to minimize solid waste generation throughout the duration of the project. .

3.8 HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

If during excavation or other construction activities any previously unidentified or unanticipated historical, archaeological, and cultural resources are discovered or found, all activities that may damage or alter such resources will be temporarily suspended. Resources covered by this paragraph include but are not limited to: any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; rock or coral alignments, pavings, wall, or other constructed features; and any indication of agricultural or other human activities. Upon such discovery or find, immediately notify the Contracting Officer so that the appropriate authorities may be notified and a determination made as to their significance and what, if any, special disposition of the finds should be made. Cease all activities that may result in impact to or the destruction of these resources. Secure the area and prevent employees or other persons from trespassing on, removing, or otherwise disturbing such resources.

3.9 BIOLOGICAL RESOURCES

Minimize interference with, disturbance to, and damage to fish, wildlife, and plants including their habitat. The protection of threatened and endangered animal and plant species, including their habitat, is the Contractor's responsibility in accordance with USFK, National, Provincial and/or Local laws, requirements, and regulations

3.10 PREVIOUSLY USED EQUIPMENT

Clean all previously used construction equipment prior to bringing it onto the project site. Ensure that the equipment is free from soil residuals, egg deposits from plant pests, noxious weeds, and plant seeds.

3.11 MAINTENANCE OF POLLUTION FACILITIES

Maintain permanent and temporary pollution control facilities and devices for the duration of the contract or for that length of time construction activities create the particular pollutant.

3.12 MILITARY MUNITIONS

In the event military munitions, as defined in 40 CFR 260, are discovered or uncovered, the Contractor will immediately stop work in that area and immediately inform the Contracting Officer.

3.13 TRAINING OF CONTRACTOR PERSONNEL

The Contractor's personnel must be trained in all phases of environmental protection and pollution control. Conduct environmental protection/pollution control meetings for all personnel prior to commencing construction activities. Additional meetings must be conducted for new personnel and when site conditions change. Include in the training and meeting agenda: methods of detecting and avoiding pollution; familiarization with statutory and contractual pollution standards; installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental protection/pollution control; anticipated hazardous or toxic chemicals or wastes, and other regulated contaminants; recognition and protection of archaeological sites, artifacts, wetlands, and endangered species and their habitat that are known to be in the area.

3.14 CONTAMINATED MEDIA MANAGEMENT

Manage contaminated environmental media consisting of, but not limited to, ground water, soils, and sediments in accordance with Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL.

3.15 POST CONSTRUCTION CLEANUP

The Contractor will clean up all areas used for construction in accordance with Contract Clause: "Cleaning Up". Unless otherwise instructed in writing by the Contracting Officer, obliterate all signs of temporary construction facilities such as haul roads, work area, structures, foundations of temporary structures, stockpiles of excess or waste materials, and other vestiges of construction prior to final acceptance of the work. The disturbed area must be graded, filled and the entire area seeded unless otherwise indicated.

-- End of Section --

SECTION 01 58 00

PROJECT IDENTIFICATION
08/09

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Construction Project Sign; G

1.2 PROJECT SIGN

1.2.1 Construction Project Sign

Furnish construction project signs, maintain the signs during construction, and remove the signs from the job site upon completion of the project. The requirements for the signs and their content shall be as shown on the drawing at the end of this section. The signs shall be erected within 15 days after receipt of the notice to proceed. Upon completion of the project, the signs shall be removed from the site.

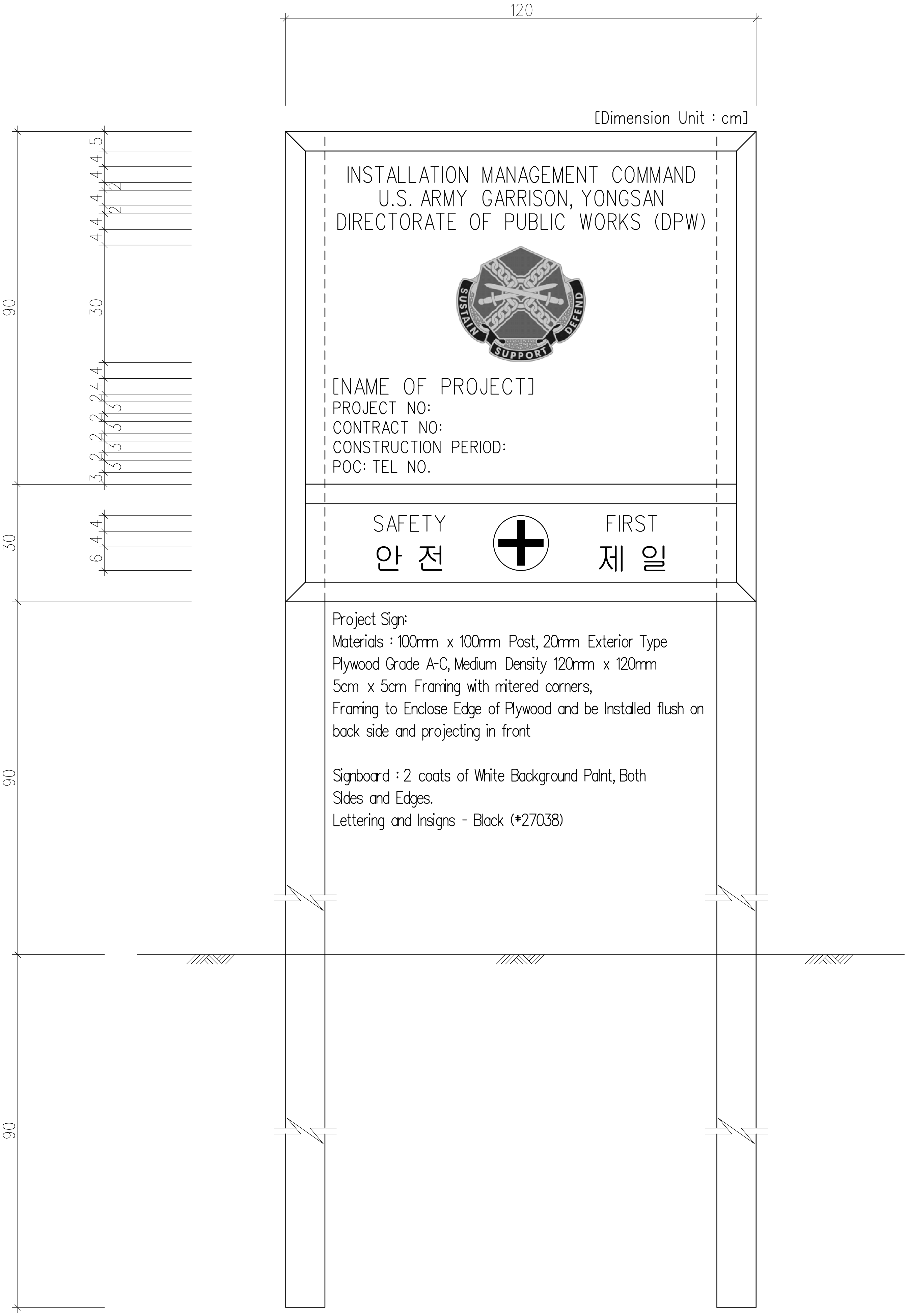
PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --



120
[Dimension Unit : cm]
90
30
90
90
INSTALLATION MANAGEMENT COMMAND
U.S. ARMY GARRISON, YONGSAN
DIRECTORATE OF PUBLIC WORKS (DPW)
SUSTAIN
SUPPORT
DEFEND
[NAME OF PROJECT]
PROJECT NO:
CONTRACT NO:
CONSTRUCTION PERIOD:
POC: TEL NO.
SAFETY
안 전
FIRST
제 일
Project Sign:
Materials : 100mm x 100mm Post, 20mm Exterior Type
Plywood Grade A-C, Medium Density 120mm x 120mm
5cm x 5cm Framing with mitered corners,
Framing to Enclose Edge of Plywood and be Installed flush on
back side and projecting in front
Signboard : 2 coats of White Background Paint, Both
Sides and Edges.
Lettering and Insigns - Black (#27038)

SECTION 01 74 19

CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED GBDC	LEED Reference Guide for Green Building Design and Construction
LEED NC	Leadership in Energy and Environmental Design(tm) New Construction Rating System

1.2 GOVERNMENT POLICY

Government policy is to apply sound environmental principles in the design, construction and use of facilities. As part of the implementation of that policy: (1) practice efficient waste management when sizing, cutting, and installing products and materials and (2) use all reasonable means to divert construction and demolition waste from landfills and incinerators and to facilitate their recycling or reuse. A minimum of 50 percent by weight of total project solid waste shall be diverted from the landfill.

1.3 MANAGEMENT

Develop and implement a waste management program. Take a pro-active, responsible role in the management of construction and demolition waste and require all subcontractors, vendors, and suppliers to participate in the effort. Construction and demolition waste includes products of demolition or removal, excess or unusable construction materials, packaging materials for construction products, and other materials generated during the construction process but not incorporated into the work. In the management of waste consideration shall be given to the availability of viable markets, the condition of the material, the ability to provide the material in suitable condition and in a quantity acceptable to available markets, and time constraints imposed by internal project completion mandates. The Contractor is responsible for implementation of any special programs involving rebates or similar incentives related to recycling of waste. Revenues or other savings obtained for salvage, or recycling accrue to the Contractor. Appropriately permit firms and facilities used for recycling, reuse, and disposal for the intended use to the extent required by USFK, ROK and local regulations. Also, provide on-site instruction of appropriate separation, handling, recycling, salvage, reuse, and return methods to be used by all parties at the appropriate stages of the project.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Waste Management Plan; G (LEED NC)

SD-11 Closeout Submittals

Records; (LEED NC)

1.5 MEETINGS

Conduct Construction Waste Management meetings. After award of the Contract and prior to commencement of work, schedule and conduct a meeting with the Contracting Officer to discuss the proposed Waste Management Plan and to develop a mutual understanding relative to the details of waste management. The requirements for this meeting may be fulfilled during the coordination and mutual understanding meeting outlined in Section 01 45 00.00 10 QUALITY CONTROL. At a minimum, environmental and waste management goals and issues shall be discussed at the following additional meetings:

a. Pre-bid meeting.

b. Preconstruction or Pre-demolition meeting.

c. Regular site or QC meetings.

d. Work safety meetings.

1.6 WASTE MANAGEMENT PLAN

A waste management plan shall be submitted within 30 days after notice to proceed and not less than 10 days before the preconstruction or pre-demolition meeting. The plan shall demonstrate how the project waste diversion goal shall be met and shall include the following:

a. Name of individuals on the Contractor's staff responsible for waste prevention and management.

b. Actions that will be taken to reduce solid waste generation, including coordination with subcontractors to ensure awareness and participation.

c. Description of the regular meetings to be held to address waste management.

d. Description of the specific approaches to be used in recycling/reuse of the various materials generated, including the areas on site and equipment to be used for processing, sorting, and temporary storage of wastes.

e. Characterization, including estimated types and quantities, of the waste to be generated.

f. Name of landfill and/or incinerator to be used and the estimated costs for use, assuming that there would be no salvage or recycling on the project.

g. Identification of local and regional reuse programs, including non-profit organizations such as schools, local housing agencies, and organizations that accept used materials such as materials exchange networks and Habitat for Humanity. Include the name, location, and phone number for each reuse facility to be used, and provide a copy of the permit or license for each facility.

h. List of specific waste materials that will be salvaged for resale, salvaged and reused on the current project, salvaged and stored for reuse on a future project, or recycled. Recycling facilities that will be used shall be identified by name, location, and phone number, including a copy of the permit or license for each facility.

i. Identification of materials that cannot be recycled/reused with an explanation or justification, to be approved by the Contracting Officer.

j. Description of the means by which any waste materials identified in item (h) above will be protected from contamination.

k. Description of the means of transportation of the recyclable materials (whether materials will be site-separated and self-hauled to designated centers, or whether mixed materials will be collected by a waste hauler and removed from the site).

l. Anticipated net cost savings determined by subtracting Contractor program management costs and the cost of disposal from the revenue generated by sale of the materials and the incineration and/or landfill cost avoidance.

Revise and resubmit Plan as required by the Contracting Officer. Approval of Contractor's Plan will not relieve the Contractor of responsibility for compliance with applicable environmental regulations or meeting project cumulative waste diversion requirement. Distribute copies of the Waste Management Plan to each subcontractor, the Quality Control Manager, and the Contracting Officer.

1.7 RECORDS

Records shall be maintained to document the quantity of waste generated; the quantity of waste diverted through sale, reuse, or recycling; and the quantity of waste disposed by landfill or incineration. Records shall be kept in accordance with the LEED GBDC and using the LEED NC Letter Template. The records shall be made available to the Contracting Officer during construction, and a copy of the records shall be delivered to the Contracting Officer upon completion of the construction included in the LEED Documentation Notebook.

Demolition accomplished by other parties on this project site count toward the project's total waste diversion cumulative score for LEED NC. Information on the quantity and disposition of these materials will be provided by the Contracting Officer. Include this data in records, annotated to indicate that it was accomplished by another party.

1.8 REPORTS

Provide quarterly reports and a final report. Quarterly and final reports shall include project name, information for waste generated this quarter, and cumulative totals for the project. Each report shall include supporting documentation to include manifests, weight tickets, receipts, and invoices specifically identifying the project and waste material. Include timber harvest and demolition information, if any.

1.9 COLLECTION

Separate, store, protect, and handle at the site identified recyclable and salvageable waste products in a manner that maximizes recyclability and salvagability of identified materials. Provide the necessary containers, bins and storage areas to facilitate effective waste management and clearly and appropriately identify them. Provide materials for barriers and enclosures around recyclable material storage areas which are nonhazardous and recyclable or reusable. Locate out of the way of construction traffic. Provide adequate space for pick-up and delivery and convenience to subcontractors. Recycling and waste bin areas are to be kept neat and clean, and recyclable materials shall be handled to prevent contamination of materials from incompatible products and materials. Clean contaminated materials prior to placing in collection containers. Use cleaning materials that are nonhazardous and biodegradable. Handle hazardous waste and hazardous materials in accordance with applicable regulations and coordinate with Section 01 57 20.00 10 ENVIRONMENTAL PROTECTION. Separate materials by one of the following methods:

1.9.1 Source Separated Method.

Waste products and materials that are recyclable shall be separated from trash and sorted as described below into appropriately marked separate containers and then transported to the respective recycling facility for further processing. Deliver materials in accordance with recycling or reuse facility requirements (e.g., free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process). Separate materials into the following category types as appropriate to the project waste and to the available recycling and reuse programs in the project area:

a. Land clearing debris.

b. Asphalt.

c. Concrete and masonry.

d. Metal (e.g. banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized, stainless steel, aluminum, copper, zinc, lead brass, bronze).

    (1) Ferrous.

    (2) Non-ferrous.

e. Wood (nails and staples allowed).

f. Debris.

g. Glass (colored glass allowed).

h. Paper.

(1) Bond.

(2) Newsprint.

(3) Cardboard and paper packaging materials.

i. Plastic.

Type	
1	Polyethylene Terephthalate (PET, PETE)
2	High Density Polyethylene (HDPE)
3	Vinyl (Polyvinyl Chloride or PVC)
4	Low Density Polyethylene (LDPE)
5	Polypropylene (PP)
6	Polystyrene (PS)
7.	Other. Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.

j. Gypsum.

k. Non-hazardous paint and paint cans.

l. Carpet.

m. Ceiling tiles.

n. Insulation.

o. Beverage containers.

1.9.2 Co-Mingled Method.

Waste products and recyclable materials shall be placed into a single container and then transported to a recycling facility where the recyclable materials are sorted and processed.

1.9.3 Other Methods.

Other methods proposed by the Contractor may be used when approved by the Contracting Officer.

1.10 DISPOSAL

Control accumulation of waste materials and trash. Recycle or dispose of collected materials off-site at intervals approved by the Contracting Officer and in compliance with waste management procedures. Except as otherwise specified in other sections of the specifications, disposal shall be in accordance with the following:

1.10.1 Reuse.

First consideration shall be given to salvage for reuse since little or no re-processing is necessary for this method, and less pollution is created when items are reused in their original form. Coordinate reuse with the Contracting Officer. (Reuse materials as indicated on the drawings or specifications.) Sale or donation of waste suitable for reuse shall be considered.

1.10.2 Recycle.

Waste materials not suitable for reuse, but having value as being recyclable, shall be made available for recycling. All fluorescent lamps, HID lamps, and mercury-containing thermostats removed from the site shall be recycled. Arrange for timely pickups from the site or deliveries to recycling facilities in order to prevent contamination of recyclable materials.

1.10.3 Compost

Consider composting on site if a reasonable amount of compostable material will be available. Compostable materials include plant material, sawdust, and certain food scraps.

1.10.4 Waste.

Materials with no practical use or economic benefit shall be disposed at a landfill or incinerator.

1.10.5 Return

Set aside and protect misdelivered and substandard products and materials and return to supplier for credit.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION 01 78 00

CLOSEOUT SUBMITTALS
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. ARMY (DA)

DA PAM 420-11	(2010) Project Definition and Work Classification

U.S. ARMY CORPS OF ENGINEERS (USACE)

TR-09-2	(2009) A/E/C (Architectural, Engineering, and Construction) CADD Standard - Release 4.0

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 1-300-08	(2009, with Change 2) Criteria for Transfer and Acceptance of DoD Real Property

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

As-Built Record of Equipment and Materials
Equipment-in-Place List
Warranty Management Plan
Warranty Tags
Spare Parts Data

SD-08 Manufacturer's Instructions

Preventative Maintenance
Condition Monitoring (Predictive Testing)
Inspection
Posted Instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings
Interim Form DD1354; G
Checklist for Form DD1354; G

1.3 PROJECT RECORD DOCUMENTS

1.3.1 Record Drawings

Drawings showing final as-built conditions of the project. This paragraph covers record drawings complete, as a requirement of the contract. The terms "drawings," "contract drawings," "drawing files," "working record drawings" and "final record drawings" refer to contract drawings which are revised to be used for final record drawings showing as-built conditions. The final record drawings must consist of one set of electronic drawing files in each of the specified formats (CAD or PDF), one set of prints, and one set of the approved working Record Drawings.

1.3.1.1 Government Furnished Materials

One set of electronic CADD files in the specified software and format revised to reflect all bid amendments will be provided by the Government at the preconstruction conference for projects requiring CADD file record drawings.

1.3.1.2 Working Record and Final Record Drawings

Revise 1 set of paper drawings by red-line process to show the as-built conditions during the prosecution of the project. Keep these working as-built marked drawings current on a weekly basis and at least one set available on the jobsite at all times. Changes from the contract plans which are made in the work or additional information which might be uncovered in the course of construction must be accurately and neatly recorded as they occur by means of details and notes. Prepare final record (as-built) drawings after the completion of each definable feature of work as listed in the Contractor Quality Control Plan (Foundations, Utilities, Structural Steel, etc., as appropriate for the project). The working as-built marked prints and final record (as-built) drawings will be jointly reviewed for accuracy and completeness by the Contracting Officer and the Contractor prior to submission of each monthly pay estimate. If the Contractor fails to maintain the working and final record drawings as specified herein, the Contracting Officer will deduct from the monthly progress payment an amount representing the estimated cost of maintaining the record drawings. This monthly deduction will continue until an agreement can be reached between the Contracting Officer and the Contractor regarding the accuracy and completeness of updated drawings. Show on the working and final record drawings, but not limited to, the following information:

a. The actual location, kinds and sizes of all sub-surface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, show by offset dimensions to two permanently fixed surface features the end of each run including each change in direction on the record drawings. Locate valves, splice boxes and similar appurtenances by dimensioning along the utility run from a reference point. Also record the average depth below the surface of each run.

b. The location and dimensions of any changes within the building structure.

c. Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.

d. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, dimensions of equipment foundations, etc.

e. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

f. Changes or modifications which result from the final inspection.

g. Where contract drawings or specifications present options, show only the option selected for construction on the final as-built prints.

h. If borrow material for this project is from sources on Government property, or if Government property is used as a spoil area, furnish a contour map of the final borrow pit/spoil area elevations.

i. Systems designed or enhanced by the Contractor, such as HVAC controls, fire alarm, fire sprinkler, and irrigation systems.

j. Modifications (include within change order price the cost to change working and final record drawings to reflect modifications) and compliance with the following procedures.

   (1) Follow directions in the modification for posting descriptive changes.

   (2) Place a Modification Circle or Delta at the location of each deletion.

   (3) For new details or sections which are added to a drawing, place a Modification Circle or Delta by the detail or section title.

   (4) For minor changes, place a Modification Circle or Delta by the area changed on the drawing (each location).

   (5) For major changes to a drawing, place a Modification Circle or Delta by the title of the affected plan, section, or detail at each location.

   (6) For changes to schedules or drawings, place a Modification Circle or Delta either by the schedule heading or by the change in the schedule.

   (7) The Modification Circle or Delta size shall be 13 mm (1/2 inch) diameter unless the area where the circle is to be placed is crowded. Smaller size circle shall be used for crowded areas.

1.3.1.3 Drawing Preparation

Modify the record drawings as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. These working as-built marked prints must be neat, legible and accurate. These drawings are part of the permanent records of this project and must be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor must be satisfactorily replaced by the Contractor at no expense to the Government.

1.3.1.4 Computer Aided Design and Drafting (CADD) Drawings

Only employ personnel proficient in the preparation of CADD drawings to modify the contract drawings or prepare additional new drawings. Additions and corrections to the contract drawings must be equal in quality and detail to that of the originals. Line colors, line weights, lettering, layering conventions, and symbols must be the same as the original line colors, line weights, lettering, layering conventions, and symbols. If additional drawings are required, prepare them using the specified electronic file format applying TR-09-2. The title block and drawing border to be used for any new final record drawings must be identical to that used on the contract drawings. Accomplish additions and corrections to the contract drawings using CADD files. The Contractor will be furnished "as-designed" drawings in Microstation format compatible with a Windows 7 operating system. The electronic files will be supplied on compact disc, read-only memory (CD-ROM). Provide all program files and hardware necessary to prepare final record drawings. The Contracting Officer will review final record drawings for accuracy and return them to the Contractor for required corrections, changes, additions, and deletions.

a. Provide CADD "base" colors of red, green, and blue. Color code for changes as follows:

   (1) Deletions (Red) - Over-strike deleted graphic items (lines), lettering in notes and leaders.

   (2) Additions (Green) - Added items, lettering in notes and leaders.

   (3) Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes.

b. Rename the Contract Drawing files in a manner related to the contract number (i.e., 98-C-10.DGN) as instructed in the Pre-Construction conference. Use only those renamed files for the Marked-up changes. All changes shall be made on the layer/level as the original item.

c. When final revisions have been completed, show the wording "RECORD DRAWINGS / AS-BUILT CONDITIONS" followed by the name of the Contractor in letters at least 5 mm (3/16 inch) high on the cover sheet drawing. Mark all other contract drawings either "Record" drawing denoting no revisions on the sheet or "Revised Record" denoting one or more revisions. Date original contract drawings in the revision block.

d. Within 10 days for contracts less than $5 million after Government approval of all of the working record drawings for a phase of work, prepare the final CADD record drawings for that phase of work and submit two sets of blue-lined prints of these drawings for Government review and approval. The Government will promptly return one set of prints annotated with any necessary corrections. Within 7 days for contracts less than $5 million revise the CADD files accordingly at no additional cost and submit one set of final prints for the completed phase of work to the Government. Within 10 days for contracts less than $5 million of substantial completion of all phases of work, submit the final record drawing package for the entire project. Submit one set of electronic files on compact disc, read-only memory (CD-ROM), two sets of blue-line prints, and one set of the approved working record drawings. They must be complete in all details and identical in form and function to the contract drawing files supplied by the Government. Any transactions or adjustments necessary to accomplish this are the responsibility of the Contractor. The Government reserves the right to reject any drawing files it deems incompatible with the customer's CADD system. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final record drawing files and marked prints as specified will be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final record drawings must be accomplished before final payment is made to the Contractor.

1.3.1.5 Payment

No separate payment will be made for record drawings required under this contract, and all costs accrued in connection with such drawings are considered a subsidiary obligation of the Contractor.

1.3.2 As-Built Record of Equipment and Materials

Furnish one copy of preliminary record of equipment and materials used on the project 30 days prior to final inspection. This preliminary submittal will be reviewed and returned 7 days after final inspection with Government comments. Submit one hard copy and one digital (PDF - text searchable) set of final record of equipment and materials no more than 10 days after final inspection. Key the designations to the related area depicted on the contract drawings. List the following data:

RECORD OF DESIGNATED EQUIPMENT AND MATERIALS DATA					
Description	Specification Section	Manufacturer and Catalog, Model, and Serial Number	Composition and Size	Where Used	Total Cost

1.3.3 Final Approved Shop Drawings

Furnish final approved project shop drawings 15 days after transfer of the completed facility.

1.3.4 Real Property

Furnish a list of equipment in place (EIP) (personal property as defined in DA PAM 420-11, paragraph 2-8.a.) furnished under this contract. Include all information usually listed on manufacturer's name plate. In the "EQUIPMENT-IN-PLACE LIST" include, as applicable, the following for each piece of equipment installed: description of item, location (by room number), model number, serial number, capacity, name and address of manufacturer, name and address of equipment supplier, condition, spare parts list, manufacturer's catalog, and warranty. Furnish a draft list at time of transfer. Furnish the final list 15 days after transfer of the completed facility.

1.4 SPARE PARTS DATA

Submit one hard copy and one digital (PDF - text searchable) copy of the Spare Parts Data list.

a. Indicate manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair. List those items that may be standard to the normal maintenance of the system.

b. Supply one item or 10% of the total quantity of items installed (rounded up) of each part for spare parts inventory. Provision of spare parts does not relieve the Contractor of responsibilities listed under the contract guarantee provisions.

1.5 PREVENTATIVE MAINTENANCE

Submit Preventative Maintenance, Condition Monitoring (Predictive Testing) and Inspection schedules with instructions that state when systems should be retested.

a. Define the anticipated length of each test, test apparatus, number of personnel identified by responsibility, and a testing validation procedure permitting the record operation capability requirements within the schedule. Provide a signoff blank for the Contractor and Contracting Officer for each test feature; e.g., liter per second, rpm, kilopascal (gpm, rpm, psi). Include a remarks column for the testing validation procedure referencing operating limits of time, pressure, temperature, volume, voltage, current, acceleration, velocity, alignment, calibration, adjustments, cleaning, or special system notes. Delineate procedures for preventative maintenance, inspection, adjustment, lubrication and cleaning necessary to minimize corrective maintenance and repair.

b. Repair requirements must inform operators how to check out, troubleshoot, repair, and replace components of the system. Include electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting of the system after acceptance.

1.6 WARRANTY MANAGEMENT

1.6.1 Warranty Management Plan

Develop a warranty management plan which contains information relevant to the clause Warranty of Construction. At least 30 days before the planned pre-warranty conference, submit one digital copy (PDF - text searchable) of the warranty management plan. Include within the warranty management plan all required actions and documents to assure that the Government receives all warranties to which it is entitled. The plan must be in narrative form and contain sufficient detail to render it suitable for use by future maintenance and repair personnel, whether tradesmen, or of engineering background, not necessarily familiar with this contract. The term "status" as indicated below must include due date and whether item has been submitted or was accomplished. Warranty information made available during the construction phase must be submitted to the Contracting Officer for approval prior to each monthly pay estimate. Assemble approved information in a binder and turn over to the Government upon acceptance of the work. The construction warranty period will begin on the date of project acceptance and continue for the full product warranty period. A joint 4 month and 9 month warranty inspection will be conducted, measured from time of acceptance, by the Contractor, Contracting Officer and the Customer Representative. Include within the warranty management plan , but not limited to, the following:

a. Roles and responsibilities of all personnel associated with the warranty process, including points of contact and telephone numbers within the organizations of the Contractors, subcontractors, manufacturers or suppliers involved.

b. Furnish with each warranty the name, address, and telephone number of each of the guarantor's representatives nearest to the project location.

c. Listing and status of delivery of all Certificates of Warranty for extended warranty items, to include roofs, HVAC balancing, pumps, motors, transformers, and for all commissioned systems such as fire protection and alarm systems, sprinkler systems, lightning protection systems, etc.

d. A list for each warranted equipment, item, feature of construction or system indicating:

   (1) Name of item.
   (2) Model and serial numbers.
   (3) Location where installed.
   (4) Name and phone numbers of manufacturers or suppliers.
   (5) Names, addresses and telephone numbers of sources of spare parts.
   (6) Warranties and terms of warranty. Include one-year overall warranty of construction, including the starting date of warranty of construction. Items which have extended warranties must be indicated with separate warranty expiration dates.
   (7) Cross-reference to warranty certificates as applicable.
   (8) Starting point and duration of warranty period.
   (9) Summary of maintenance procedures required to continue the warranty in force.
   (10) Cross-reference to specific pertinent Operation and Maintenance manuals.
   (11) Organization, names and phone numbers of persons to call for warranty service.
   (12) Typical response time and repair time expected for various warranted equipment.

e. The Contractor's plans for attendance at the 4 and 9 month post-construction warranty inspections conducted by the Government.

f. Procedure and status of tagging of all equipment covered by extended warranties.

g. Copies of instructions to be posted near selected pieces of equipment where operation is critical for warranty and/or safety reasons.

1.6.2 Performance Bond

The Contractor's Performance Bond must remain effective throughout the construction period .

a. In the event the Contractor fails to commence and diligently pursue any construction warranty work required, the Contracting Officer will have the work performed by others, and after completion of the work, will charge the remaining construction warranty funds of expenses incurred by the Government while performing the work, including, but not limited to administrative expenses.

b. In the event sufficient funds are not available to cover the construction warranty work performed by the Government at the Contractor's expense, the Contracting Officer will have the right to recoup expenses from the bonding company.

c. Following oral or written notification of required construction warranty repair work, respond in a timely manner. Written verification will follow oral instructions. Failure of the Contractor to respond will be cause for the Contracting Officer to proceed against the Contractor.

1.6.3 Pre-Warranty Conference

Prior to contract completion, and at a time designated by the Contracting Officer, meet with the Contracting Officer to develop a mutual understanding with respect to the requirements of this section. Communication procedures for Contractor notification of construction warranty defects, priorities with respect to the type of defect, reasonable time required for Contractor response, and other details deemed necessary by the Contracting Officer for the execution of the construction warranty will be established/reviewed at this meeting. In connection with these requirements and at the time of the Contractor's quality control completion inspection, furnish the name, telephone number and address of a licensed and bonded company which is authorized to initiate and pursue construction warranty work action on behalf of the Contractor. This point of contact will be located within the local service area of the warranted construction, be continuously available, and be responsive to Government inquiry on warranty work action and status. This requirement does not relieve the Contractor of any of its responsibilities in connection with other portions of this provision.

1.6.4 Contractor's Response to Construction Warranty Service Requirements

Following oral or written notification by the Contracting Officer, respond to construction warranty service requirements in accordance with the "Construction Warranty Service Priority List" and the three categories of priorities listed below. Submit a report on any warranty item that has been repaired during the warranty period. Include within the report the cause of the problem, date reported, corrective action taken, and when the repair was completed. If the Contractor does not perform the construction warranty within the time frames specified, the Government will perform the work and charge the construction warranty payment item established.

a. First Priority Code 1. Perform onsite inspection to evaluate situation, and determine course of action within 4 hours, initiate work within 6 hours and work continuously to completion or relief.

b. Second Priority Code 2. Perform onsite inspection to evaluate situation, and determine course of action within 8 hours, initiate work within 24 hours and work continuously to completion or relief.

c. Third Priority Code 3. All other work to be initiated within 3 work days and work continuously to completion or relief.

d. The "Construction Warranty Service Priority List" is as follows:

Code 1-Life Safety Systems
(1) Fire suppression systems.
(2) Fire alarm system(s) in place in the building.

Code 1-Air Conditioning Systems
(1) Recreational support.
(2) Air conditioning leak in part of building, if causing damage.
(3) Air conditioning system not cooling properly.

Code 1-Doors
(1) Overhead doors not operational, causing a security, fire, or safety problem.
(2) Interior, exterior personnel doors or hardware, not functioning properly, causing a security, fire, or safety problem.

Code 3-Doors
(1) Overhead doors not operational.
(2) Interior/exterior personnel doors or hardware not functioning properly.

Code 1-Electrical
(1) Power failure (entire area or any building operational after 1600 hours).
(2) Security lights
(3) Smoke detectors

Code 2-Electrical
(1) Power failure (no power to a room or part of building).
(2) Receptacle and lights (in a room or part of building).

Code 3-Electrical
Street lights.

Code 1-Gas
(1) Leaks and breaks.
(2) No gas to family housing unit or cantonment area.

Code 1-Heat
(1) Area power failure affecting heat.
(2) Heater in unit not working.

Code 2-Kitchen Equipment
(1) Dishwasher not operating properly.
(2) All other equipment hampering preparation of a meal.

Code 1-Plumbing
(1) Hot water heater failure.
(2) Leaking water supply pipes.

Code 2-Plumbing

(1) Flush valves not operating properly.
(2) Fixture drain, supply line to commode, or any water pipe leaking.
(3) Commode leaking at base.

Code 3 -Plumbing
Leaky faucets.

Code 3-Interior
(1) Floors damaged.
(2) Paint chipping or peeling.
(3) Casework.

Code 1-Roof Leaks
Temporary repairs will be made where major damage to property is occurring.

Code 2-Roof Leaks
Where major damage to property is not occurring, check for location of leak during rain and complete repairs on a Code 2 basis.

Code 2-Water (Exterior)
No water to facility.

Code 2-Water (Hot)
No hot water in portion of building listed.

Code 3-All other work not listed above.

1.6.5 Warranty Tags

At the time of installation, tag each warranted item with a durable, oil and water resistant tag approved by the Contracting Officer. Attach each tag with a copper wire and spray with a silicone waterproof coating. Also, submit two record copies of the warranty tags showing the layout and design. The date of acceptance and the QC signature must remain blank until the project is accepted for beneficial occupancy. Show the following information on the tag.

Type of product/material	
Model number	
Serial number	
Contract number	
Warranty period from/to	
Inspector's signature	
Construction Contractor	
Address	
Telephone number	

Warranty contact	
Address	
Telephone number	
Warranty response time priority code	
WARNING - PROJECT PERSONNEL TO PERFORM ONLY OPERATIONAL MAINTENANCE DURING THE WARRANTY PERIOD.	

1.7 OPERATION AND MAINTENANCE MANUALS

Submit one hard copy and one digital copy (.pdf - text searchable; if scanning documents, use Optical Character Recognition (OCR)) of the project operation and maintenance manuals 30 calendar days prior to testing the system involved. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion. For Air Force projects, submit two hard copies and four Digital Video Discs (DVD) with digital copies.

1.7.1 Configuration

Operation and Maintenance Manuals must be consistent with the manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions. Bind information in manual format and grouped by technical sections. Test data must be legible and of good quality. Light-sensitive reproduction techniques are acceptable provided finished pages are clear, legible, and not subject to fading. Pages for vendor data and manuals must have 10 millimeter 0.3937-inch holes and be bound in 3-ring, loose-leaf binders. Organize data by separate index and tabbed sheets, in a loose-leaf binder. Binder must lie flat with printed sheets that are easy to read. Caution and warning indications must be clearly labeled.

1.7.2 Training and Instruction

Submit classroom and field instructions in the operation and maintenance of systems equipment where required by the technical provisions. These services must be directed by the Contractor, using the manufacturer's factory-trained personnel or qualified representatives. Contracting Officer will be given 7 calendar days written notice of scheduled instructional services. Instructional materials belonging to the manufacturer or vendor, such as lists, static exhibits, and visual aids, must be made available to the Contracting Officer.

1.8 CLEANUP

Leave premises "broom clean." Clean interior and exterior glass surfaces exposed to view; remove temporary labels, stains and foreign substances; polish transparent and glossy surfaces; vacuum carpeted and soft surfaces. Clean equipment and fixtures to a sanitary condition. Replace filters of operating equipment. Clean debris from roofs, gutters, downspouts and drainage systems. Sweep paved areas and rake clean landscaped areas. Remove waste and surplus materials, rubbish and construction facilities from the site.

1.9 REAL PROPERTY RECORD

Near the completion of Project, but a minimum of 30 days prior to final acceptance of the work, complete and submit an accounting of all installed property with Interim Form DD1354 "Transfer and Acceptance of Military Real Property." Include any additional assets/improvements/alterations from the Draft DD Form 1354. Contact the Contracting Officer for any project specific information necessary to complete the DD Form 1354. Refer to UFC 1-300-08 for instruction on completing the DD Form 1354. For information purposes, a blank DD Form 1354 (fill-able) in ADOBE (PDF) may be obtained at the following web site:
http://www.dtic.mil/whs/directives/infomgt/forms/eforms/dd1354.pdf

Submit the completed Checklist for Form DD1354 of Installed Building Equipment items. Attach this list to the updated DD Form 1354. Failure to have this form completed and approved in time for the final inspection will result in delay of the inspection until the checklist is completed.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA
07/06

PART 1 GENERAL

1.1 SUBMISSION OF OPERATION AND MAINTENANCE DATA

Submit Operation and Maintenance (O&M) Data specifically applicable to this contract and a complete and concise depiction of the provided equipment, product, or system, stressing and enhancing the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation. The subcontractors must compile and prepare data and deliver to the Contractor prior to the training of Government personnel. The Contractor must compile and prepare aggregate O&M data including clarifying and updating the original sequences of operation to as-built conditions. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal. Submit in accordance with this section and Section 01 33 00 SUBMITTAL PROCEDURES.

1.1.1 Package Quality

Documents must be fully legible. Poor quality copies and material with hole punches obliterating the text or drawings will not be accepted.

1.1.2 Package Content

Data package content shall be as shown in the paragraph titled "Schedule of Operation and Maintenance Data Packages." Comply with the data package requirements specified in the individual technical sections, including the content of the packages and addressing each product, component, and system designated for data package submission, except as follows. Commissioned items without a specified data package requirement in the individual technical sections must use Data Package 3. Commissioned items with a Data Package 1 or 2 requirement must use instead Data Package 3.

1.1.3 Changes to Submittals

Manufacturer-originated changes or revisions to submitted data must be furnished by the Contractor if a component of an item is so affected subsequent to acceptance of the O&M Data. Submit changes, additions, or revisions required by the Contracting Officer for final acceptance of submitted data within 30 calendar days of the notification of this change requirement.

1.1.4 Review and Approval

The Contractor's Commissioning Authority (CA) must review the commissioned systems and equipment submittals for completeness and applicability. The CA must verify that the systems and equipment provided meet the requirements of the Contract documents and design intent, particularly as they relate to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts. The CA must communicate deficiencies to the Contracting Officer. Upon a successful review of the corrections, the CA must recommend approval and acceptance of these O&M manuals to the Contracting Officer. This work is in addition to the normal review procedures for O&M data.

1.1.5 O&M Database

Develop a database from the O&M manuals that contains the information required to start a preventative maintenance program.

1.2 TYPES OF INFORMATION REQUIRED IN O&M DATA PACKAGES

1.2.1 Operating Instructions

Include specific instructions, procedures, and illustrations for the following phases of operation for the installed model and features of each system:

1.2.1.1 Safety Precautions

List personnel hazards and equipment or product safety precautions for all operating conditions.

1.2.1.2 Operator Prestart

Include procedures required to install, set up, and prepare each system for use.

1.2.1.3 Startup, Shutdown, and Post-Shutdown Procedures

Provide narrative description for Startup, Shutdown and Post-shutdown operating procedures including the control sequence for each procedure.

1.2.1.4 Normal Operations

Provide narrative description of Normal Operating Procedures. Include Control Diagrams with data to explain operation and control of systems and specific equipment.

1.2.1.5 Emergency Operations

Include Emergency Procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include Emergency Shutdown Instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance and procedures for emergency operation of all utility systems including required valve positions, valve locations and zones or portions of systems controlled.

1.2.1.6 Operator Service Requirements

Include instructions for services to be performed by the operator such as lubrication, adjustment, inspection, and recording gage readings.

1.2.1.7 Environmental Conditions

Include a list of Environmental Conditions (temperature, humidity, and other relevant data) that are best suited for the operation of each product, component or system. Describe conditions under which the item equipment should not be allowed to run.

1.2.2 Preventive Maintenance

Include the following information for preventive and scheduled maintenance to minimize corrective maintenance and repair for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

1.2.2.1 Lubrication Data

Include preventative maintenance lubrication data, in addition to instructions for lubrication provided under paragraph titled "Operator Service Requirements":

a. A table showing recommended lubricants for specific temperature ranges and applications.

b. Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities.

c. A Lubrication Schedule showing service interval frequency.

1.2.2.2 Preventive Maintenance Plan and Schedule

Include manufacturer's schedule for routine preventive maintenance, inspections, tests and adjustments required to ensure proper and economical operation and to minimize corrective maintenance. Provide manufacturer's projection of preventive maintenance work-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft. For periodic calibrations, provide manufacturer's specified frequency and procedures for each separate operation.

1.2.3 Corrective Maintenance (Repair)

Include manufacturer's recommended procedures and instructions for correcting problems and making repairs.

1.2.3.1 Troubleshooting Guides and Diagnostic Techniques

Include step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.

1.2.3.2 Wiring Diagrams and Control Diagrams

Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type, identically to actual installation configuration and numbering.

1.2.3.3 Maintenance and Repair Procedures

Include instructions and a list of tools required to repair or restore the product or equipment to proper condition or operating standards.

1.2.3.4 Removal and Replacement Instructions

Include step-by-step procedures and a list required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings and adjustments required. Instructions shall include a combination of text and illustrations.

1.2.3.5 Spare Parts and Supply Lists

Include lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonable delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead-time to obtain.

1.2.4 Corrective Maintenance Work-Hours

Include manufacturer's projection of corrective maintenance work-hours including requirements by type of craft. Corrective maintenance that requires completion or participation of the equipment manufacturer shall be identified and tabulated separately.

1.2.5 Appendices

Provide information required below and information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment. Include the following:

1.2.5.1 Product Submittal Data

Provide a copy of all SD-03 Product Data submittals required in the applicable technical sections.

1.2.5.2 Manufacturer's Instructions

Provide a copy of all SD-08 Manufacturer's Instructions submittals required in the applicable technical sections.

1.2.5.3 O&M Submittal Data

Provide a copy of all SD-10 Operation and Maintenance Data submittals required in the applicable technical sections.

1.2.5.4 Parts Identification

Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number that will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies in accordance with the manufacturer's standard practice. Parts data may cover more than one model or series of equipment, components, assemblies, subassemblies, attachments, or accessories, such as typically shown in a master parts catalog

1.2.5.5 Warranty Information

List and explain the various warranties and clearly identify the servicing and technical precautions prescribed by the manufacturers or contract documents in order to keep warranties in force. Include warranty information for primary components such as the compressor of air conditioning system.

1.2.5.6 Personnel Training Requirements

Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems.

1.2.5.7 Testing Equipment and Special Tool Information

Include information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.2.5.8 Testing and Performance Data

Include completed prefunction checklists, functional performance test forms, and monitoring reports. Include recommended schedule for retesting and blank test forms.

1.2.5.9 Contractor Information

Provide a list that includes the name, address, and telephone number of the General Contractor and each Subcontractor who installed the product or equipment, or system. For each item, also provide the name address and telephone number of the manufacturer's representative and service organization that can provide replacements most convenient to the project site. Provide the name, address, and telephone number of the product, equipment, and system manufacturers.

1.3 TYPES OF INFORMATION REQUIRED IN CONTROLS O&M DATA PACKAGES

Include Data Package 5 and the following for control systems:

a. Narrative description on how to perform and apply all functions, features, modes, and other operations, including unoccupied operation, seasonal changeover, manual operation, and alarms. Include detailed technical manual for programming and customizing control loops and algorithms.

b. Full as-built sequence of operations.

c. Copies of all checkout tests and calibrations performed by the Contractor (not Cx tests).

d. Full points list. A listing of rooms shall be provided with the following information for each room:

   (1) Floor

(2) Room number

(3) Room name

(4) Air handler unit ID

(5) Reference drawing number

(6) Air terminal unit tag ID

(7) Heating and/or cooling valve tag ID

(8) Minimum cfm

(9) Maximum cfm

e. Full print out of all schedules and set points after testing and acceptance of the system.

f. Full as-built print out of software program.

g. Electronic File:

(1) Assemble each manual into a composite electronically indexed file in PDF format. Provide HDD’s, DVD's or CD's as appropriate, so that each one contains all maintenance and record files, and also the Project Record Documents and Training Videos, of the entire program for this facility.

(2) Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.

(3) Link the index to separate files within the composite of files. Book mark maintenance and record files that have a Table of Contents, according to the Table of Contents

h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.

1.4 SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES

Furnish the O&M data packages specified in individual technical sections. The required information for each O&M data package is as follows:

1.4.1 Data Package 1

a. Safety precautions

b. Cleaning recommendations

c. Maintenance and repair procedures

d. Warranty information

e. Contractor information

f. Spare parts and supply list

1.4.2 Data Package 2

a. Safety precautions

b. Normal operations

c. Environmental conditions

d. Lubrication data

e. Preventive maintenance plan and schedule

f. Cleaning recommendations

g. Maintenance and repair procedures

h. Removal and replacement instructions

i. Spare parts and supply list

j. Parts identification

k. Warranty information

l. Contractor information

1.4.3 Data Package 3

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and post-shutdown procedures

d. Normal operations

e. Emergency operations

f. Environmental conditions

g. Lubrication data

h. Preventive maintenance plan and schedule

i. Cleaning recommendations

j. Troubleshooting guides and diagnostic techniques

k. Wiring diagrams and control diagrams

l. Maintenance and repair procedures

m. Removal and replacement instructions

n. Spare parts and supply list

o. Product submittal data

p. O&M submittal data

q. Parts identification

r. Warranty information

s. Testing equipment and special tool information

t. Testing and performance data

u. Contractor information

1.4.4 Data Package 4

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and post-shutdown procedures

d. Normal operations

e. Emergency operations

f. Operator service requirements

g. Environmental conditions

h. Lubrication data

i. Preventive maintenance plan and schedule

j. Cleaning recommendations

k. Troubleshooting guides and diagnostic techniques

l. Wiring diagrams and control diagrams

m. Maintenance and repair procedures

n. Removal and replacement instructions

o. Spare parts and supply list

p. Corrective maintenance man-hours

q. Product submittal data

r. O&M submittal data

s. Parts identification

t. Warranty information

u. Personnel training requirements

v. Testing equipment and special tool information

w. Testing and performance data

x. Contractor information

1.4.5 Data Package 5

a. Safety precautions

b. Operator prestart

c. Start-up, shutdown, and post-shutdown procedures

d. Normal operations

e. Environmental conditions

f. Preventive maintenance plan and schedule

g. Troubleshooting guides and diagnostic techniques

h. Wiring and control diagrams

i. Maintenance and repair procedures

j. Removal and replacement instructions

k. Spare parts and supply list

l. Product submittal data

m. Manufacturer's instructions

n. O&M submittal data

o. Parts identification

p. Testing equipment and special tool information

q. Warranty information

r. Testing and performance data

s. Contractor information

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 02 41 00

DEMOLITION AND DECONSTRUCTION
05/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI Guideline K	(2009) Guideline for Containers for Recovered Non-Flammable Fluorocarbon Refrigerants

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 145	(1991; R 2008) Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE A10.6	(2006) Safety Requirements for Demolition Operations

CARPET AND RUG INSTITUTE (CRI)

CRI 104	(2002) Standard for Installation Specification of Commercial Carpet

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. DEFENSE LOGISTICS AGENCY (DLA)

DLA 4145.25	(June 2000) Storage and Handling of Liquefied and Gaseous Compressed Gases and Their Full and Empty Cylinders

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 4000.25-1-M	(2006) MILSTRIP - Military Standard Requisitioning and Issue Procedures
MIL-STD-129	(2007; Rev P; Change 4 2007) Military Marking for Shipment and Storage

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 61	National Emission Standards for Hazardous Air Pollutants
40 CFR 82	Protection of Stratospheric Ozone
49 CFR 173.301	Shipment of Compressed Gases in Cylinders and Spherical Pressure Vessels

REPUBLIC OF KOREA (ROK) LAW

Act No. 10911	(25 JUL 2011) Korean Waste Management Act (WMA)
PD No. 22889	(6 APR 2011) Korean Presidential Decree (PD) of WMA
MD No. 406	(31 MAR 2011) Korean Ministry of Environment, Ministerial Decree (MD) of WMA

1.2 PROJECT DESCRIPTION

1.2.1 Demolition/Deconstruction Plan

Prepare a Demolition Plan or Deconstruction Plan and submit proposed salvage, demolition, deconstruction, and removal procedures for approval before work is started. Include in the plan procedures for careful removal and disposition of materials specified to be salvaged, coordination with other work in progress, a disconnection schedule of utility services, and airfield lighting, a detailed description of methods and equipment to be used for each operation and of the sequence of operations. Coordinate with Waste Management Plan. Include statements affirming Contractor inspection of the existing roof deck and its suitability to perform as a safe working platform or if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the work. Provide procedures for safe conduct of the work in accordance with EM 385-1-1. Plan shall be approved by Contracting Officer or Civil PE prior to work beginning.

1.2.2 General Requirements

Do not begin demolition or deconstruction until authorization is received from the Contracting Officer. The work includes demolition, deconstruction, salvage of identified items and materials, and removal of resulting rubbish and debris. Remove rubbish and debris from Government property daily, unless otherwise directed. Store materials that cannot be removed daily in areas specified by the Contracting Officer. In the interest of occupational safety and health, perform the work in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections.

1.3 ITEMS TO REMAIN IN PLACE

Take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government. Repair or replace damaged items as approved by the Contracting Officer. Coordinate the work of this section with all other work indicated. Construct and maintain shoring, bracing, and supports as required. Ensure that structural elements are not overloaded. Increase structural supports or add new supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract. Do not overload structural elements . Provide new supports and reinforcement for existing construction weakened by demolition, deconstruction, or removal work. Repairs, reinforcement, or structural replacement require approval by the Contracting Officer prior to performing such work.

1.3.1 Existing Construction Limits and Protection

Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide temporary shoring and bracing for support of building components to prevent settlement or other movement. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove snow, dust, dirt, and debris from work areas daily.

1.3.2 Weather Protection

For portions of the building to remain, protect building interior and materials and equipment from the weather at all times. Where removal of existing roofing is necessary to accomplish work, have materials and workmen ready to provide adequate and temporary covering of exposed areas.

1.3.3 Trees

Protect trees within the project site that might be damaged during demolition or deconstruction, and which are indicated to be left in place, by a 1.8 m (6 foot) high fence. Erect and secure fence a minimum of 1.5 m 5 feet) from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Replace any tree designated to remain that is damaged during the work under this contract with like-kind or as approved by the Contracting Officer.

1.3.4 Utility Service

Maintain existing utilities indicated to stay in service and protect against damage during demolition and deconstruction operations. Prior to start of work, utilities serving each area of alteration or removal will be shut off by the Government and disconnected and sealed by the Contractor.

1.3.5 Facilities

Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities. Floors, roofs, walls, columns, pilasters, and other structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, must remain standing without additional bracing, shoring, or lateral support until demolished or deconstructed, unless directed otherwise by the Contracting Officer. Ensure that no elements determined to be unstable are left unsupported and place and secure bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract.

1.4 BURNING

The use of burning at the project site for the disposal of refuse and debris will not be permitted.

1.5 AVAILABILITY OF WORK AREAS

Areas in which the work is to be accomplished will be as indicated on the demolition plan or as directed by the Contracting Officer.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Existing Conditions; G

SD-07 Certificates

Demolition Plan; G
Deconstruction Plan; G
Notification; G

SD-11 Closeout Submittals

Receipts

1.7 QUALITY ASSURANCE

Submit timely notification of demolition, deconstruction, and renovation projects to local authorities in accordance with 40 CFR 61, Subpart M. Notify the local air pollution control district/agency and the Contracting Officer in writing 10 working days prior to the commencement of work in accordance with 40 CFR 61, Subpart M. Comply with local hauling and disposal regulations. In addition to the requirements of the "Contract Clauses," conform to the safety requirements contained in ASSE/SAFE A10.6. Comply with the Environmental Protection Agency requirements specified. Use of explosives will not be permitted.

1.7.1 Dust and Debris Control

Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to ice, flooding, or pollution. Sweep pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to aircraft.

1.8 PROTECTION

1.8.1 Traffic Control Signs

Where pedestrian and driver safety is endangered in the area of removal work, use traffic barricades with flashing lights. Notify the Contracting Officer prior to beginning such work.

1.8.2 Protection of Personnel

Before, during and after the demolition and deconstruction work continuously evaluate the condition of the structure being demolished and deconstructed and take immediate action to protect all personnel working in and around the project site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area.

1.9 FOREIGN OBJECT DAMAGE (FOD)

Aircraft and aircraft engines are subject to FOD from debris and waste material lying on airfield pavements. Remove all such materials that may appear on operational aircraft pavements due to the Contractor's operations. If necessary, the Contracting Officer may require the Contractor to install a temporary barricade at the Contractor's expense to control the spread of FOD potential debris. The barricade shall include a fence covered with a fabric designed to stop the spread of debris. Anchor the fence and fabric to prevent displacement by winds or jet/prop blasts. Remove barricade when no longer required.

1.10 RELOCATIONS

Perform the removal and reinstallation of relocated items as indicated with workmen skilled in the trades involved. Repair or replace items to be relocated which are damaged by the Contractor with new undamaged items as approved by the Contracting Officer.

1.11 EXISTING CONDITIONS

Before beginning any demolition or deconstruction work, survey the site and examine the drawings and specifications to determine the extent of the work. Record existing conditions in the presence of the Contracting Officer showing the condition of structures and other facilities adjacent to areas of alteration or removal. Photographs sized 100 mm (4 inch will be acceptable as a record of existing conditions. Include in the record the elevation of the top of foundation walls, finish floor elevations, possible conflicting electrical conduits, plumbing lines, alarms systems, the location and extent of existing cracks and other damage and description of surface conditions that exist prior to before starting work. It is the Contractor's responsibility to verify and document all required outages which will be required during the course of work, and to note these outages on the record document. Submit survey results.

PART 2 PRODUCTS

2.1 FILL MATERIAL

a. Comply with excavating, backfilling, and compacting procedures for soils used as backfill material to fill basements, voids, depressions or excavations resulting from demolition or deconstruction of structures.

b. Fill material shall conform to the definition of satisfactory soil material as defined in AASHTO M 145, Soil Classification Groups A-1, A-2-4, A-2-5 and A-3. In addition, fill material shall be free from roots and other organic matter, trash, debris, frozen materials, and stones larger than 50 mm (2 inches) in any dimension.

PART 3 EXECUTION

3.1 EXISTING FACILITIES TO BE REMOVED

Inspect and evaluate existing structures onsite for reuse. Existing construction scheduled to be removed for reuse shall be disassembled. Dismantled and removed materials are to be separated, set aside, and prepared as specified, and stored or delivered to a collection point for reuse, remanufacture, recycling, or other disposal, as specified. Materials shall be designated for reuse onsite whenever possible.

3.1.1 Structures

a. Remove existing structures indicated to be removed to grade. Interior walls, other than retaining walls and partitions, shall be removed to top of concrete slab on ground. Break up basement slabs to permit drainage. Remove sidewalks, curbs, gutters and street light bases as indicated.

b. Demolish structures in a systematic manner from the top of the structure to the ground. Complete demolition work above each tier or floor before the supporting members on the lower level are disturbed. Demolish concrete and masonry walls in small sections. Remove structural framing members and lower to ground by means of derricks, platforms hoists, or other suitable methods as approved by the Contracting Officer.

c. Locate demolition and deconstruction equipment throughout the structure and remove materials so as to not impose excessive loads to supporting walls, floors, or framing.

d. Building, or the remaining portions thereof, not exceeding 25 m (80 feet in height may be demolished by the mechanical method of demolition.

3.1.2 Utilities and Related Equipment

3.1.2.1 General Requirements

Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the Contracting Officer. Do not interrupt existing utilities serving facilities occupied and used by the Government except when approved in writing and then only after temporary utility services have been approved and provided. Do not begin demolition or deconstruction work until all utility disconnections have been made. Shut off and cap utilities for future use, as indicated.

3.1.2.2 Disconnecting Existing Utilities

Remove existing utilities, as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by the Contracting Officer. When utility lines are encountered but are not indicated on the drawings, notify the Contracting

Officer prior to further work in that area. Remove meters and related equipment and deliver to a location in accordance with instructions of the Contracting Officer.

3.1.3 Chain Link Fencing

Remove chain link fencing, gates and other related salvaged items scheduled for removal and transport to designated areas. Remove gates as whole units. Cut chain link fabric to (25 foot lengths and store in rolls off the ground.

3.1.4 Paving and Slabs

Remove ground scarified sawcut concrete and asphaltic concrete paving and slabs including aggregate base as indicated to existing adjacent new finish grade. Provide neat sawcuts at limits of pavement removal as indicated. Pavement and slabs designated to be recycled and utilized in this project shall be moved, ground and stored as directed by the Contracting Officer. Pavement and slabs not to be used in this project shall be removed from the Installation at Contractor's expense.

3.1.5 Roofing

Remove existing roof system and associated components in their entirety down to existing roof deck. Remove built-up, single-ply roofing to effect the connections with new flashing or roofing. Remove gravel surfacing from existing roofing felts for a minimum distance of 450 mm (18 inches back from the cut. Remove gravel without damaging felts. Salvage asphalt roofing materials. Cut existing felts membrane and insulation along straight lines. Remove roofing system and insulation without damaging the roof deck. Sequence work to minimize building exposure between demolition or deconstruction and new roof materials installation.

3.1.5.1 Temporary Roofing

Install temporary roofing and flashing as necessary to maintain a watertight condition throughout the course of the work. Remove temporary work prior to installation of permanent roof system materials unless approved otherwise by the Contracting Officer. The existing deck and support structure is deteriorated where indicated, such that ability to support foot traffic and construction loads is unknown. Make provisions for worker safety during demolition, deconstruction, and installation of new materials as described in paragraphs entitled "Statements" and "Regulatory and Safety Requirements."

3.1.5.2 Reroofing

When removing the existing roofing system from the roof deck, remove only as much roofing as can be recovered by the end of the work day, unless approved otherwise by the Contracting Officer. Do not attempt to open the roof covering system in threatening weather. Reseal all openings prior to suspension of work the same day.

3.1.6 Masonry

Sawcut and remove masonry so as to prevent damage to surfaces to remain, to removed materials being salvaged and to facilitate the installation of new work. Where new masonry adjoins existing, the new work shall abut or tie into the existing construction as indicated or specified for the new work. Provide square, straight edges and corners where existing masonry adjoins new work and other locations. Masonry removed in whole blocks shall be salvaged and stored for reuse. Masonry removed in pieces shall be crushed for use as aggregate.

3.1.7 Concrete

Saw concrete along straight lines to a depth of a minimum 50 mm (2 inch. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished work, and the remaining concrete is sound. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete.

3.1.8 Structural Steel

Dismantle structural steel at field connections and in a manner that will prevent bending or damage. Salvage for reuse or recycle structural steel, steel joists, girders, angles, plates, columns and shapes. Flame-cutting torches are permitted when other methods of dismantling are not practical. Transport steel joists and girders as whole units and not dismantled. Transport structural steel shapes to a designated storage are, a recycling facility area, or as directed by the Contracting Officer, stacked according to size, type of member and length, and stored off the ground, protected from the weather.

3.1.9 Miscellaneous Metal

Salvage shop-fabricated items such as access doors and frames, steel gratings, metal ladders, wire mesh partitions, metal railings, metal windows and similar items as whole units. Salvage light-gage and cold-formed metal framing, such as steel studs, steel trusses, metal gutters, roofing and siding, metal toilet partitions, toilet accessories and similar items. Recycle scrap metal as part of demolition and deconstruction operations. Provide separate containers to collect scrap metal and transport to a scrap metal collection or recycling facility, in accordance with the Waste Management Plan.

3.1.10 Carpentry

Salvage for reuse or recycle lumber, millwork items, and finished boards, and sort by type and size. Chip or shred and recycle salvaged wood unfit for reuse, except stained, painted, or treated wood. Salvage windows, doors, frames, and cabinets, and similar items as whole units, complete with trim and accessories. Salvage hardware attached to units for reuse. Brace the open end of door frames to prevent damage.

3.1.11 Carpet

Remove existing carpet for reclamation in accordance with manufacturer recommendations and as follows. Remove used carpet in large pieces, roll tightly, and pack neatly in a container. Remove adhesive according to recommendations of the Carpet and Rug Institute (CRI). Adhesive removal solvents shall comply with CRI 104. Recycle removed carpet cushion.

3.1.12 Acoustic Ceiling Tile

Remove, neatly stack, and recycle acoustic ceiling tiles. Recycling may be available with manufacturer. Otherwise, priority shall be given to a local recycling organization.

3.1.13 Airfield Lighting

Remove existing airfield lighting as indicated and terminate in a manner satisfactory to the Contracting Officer.

3.1.14 Patching

Where removals leave holes and damaged surfaces exposed in the finished work, patch and repair these holes and damaged surfaces to match adjacent finished surfaces, using on-site materials when available. Where new work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new work. Finished surfaces of patched area shall be flush with the adjacent existing surface and shall match the existing adjacent surface as closely as possible as to texture and finish. Patching shall be as specified and indicated, and shall include:

a. Concrete and Masonry: Completely fill holes and depressions, caused by previous physical damage or left as a result of removals in existing masonry walls to remain, with an approved masonry patching material, applied in accordance with the manufacturer's printed instructions.

b. Where existing partitions have been removed leaving damaged or missing resilient tile flooring, patch to match the existing floor tile.

c. Patch acoustic lay-in ceiling where partitions have been removed. The transition between the different ceiling heights shall be effected by continuing the higher ceiling level over to the first runner on the lower ceiling and closing the vertical opening with a painted sheet metal strip.

3.1.15 Air Conditioning Equipment

Remove air conditioning, refrigeration, and other equipment containing refrigerants without releasing chlorofluorocarbon refrigerants to the atmosphere in accordance with the Clean Air Act Amendment of 1990. Recover all refrigerants prior to removing air conditioning, refrigeration, and other equipment containing refrigerants and dispose of in accordance with the paragraph entitled "Disposal of Ozone Depleting Substance (ODS)."Turn in salvaged Class I ODS refrigerants as specified in paragraph, "Salvaged Materials and Equipment."

3.1.16 Cylinders and Canisters

Remove all fire suppression system cylinders and canisters and dispose of in accordance with the paragraph entitled "Disposal of Ozone Depleting Substance (ODS)."

3.1.17 Locksets on Swinging Doors

Remove all locksets from all swinging doors indicated to be removed and disposed of. Deliver the locksets and related items to a designated location for receipt by the Contracting Officer after removal.

3.1.18 Mechanical Equipment and Fixtures

Disconnect mechanical hardware at the nearest connection to existing services to remain, unless otherwise noted. Disconnect mechanical equipment and fixtures at fittings. Remove service valves attached to the unit. Salvage each item of equipment and fixtures as a whole unit; listed, indexed, tagged, and stored. Salvage each unit with its normal operating auxiliary equipment. Transport salvaged equipment and fixtures, including motors and machines, to a designated storage area as directed by the Contracting Officer. Do not remove equipment until approved. Do not offer low-efficiency equipment for reuse; provide to recycling service for disassembly and recycling of parts.

3.1.18.1 Preparation for Storage

Remove water, dirt, dust, and foreign matter from units; tanks, piping and fixtures shall be drained; interiors, if previously used to store flammable, explosive, or other dangerous liquids, shall be steam cleaned. Seal openings with caps, plates, or plugs. Secure motors attached by flexible connections to the unit. Change lubricating systems with the proper oil or grease.

3.1.18.2 Piping

Disconnect piping at unions, flanges and valves, and fittings as required to reduce the pipe into straight lengths for practical storage. Store salvaged piping according to size and type. If the piping that remains can become pressurized due to upstream valve failure, end caps, blind flanges, or other types of plugs or fittings with a pressure gage and bleed valve shall be attached to the open end of the pipe to ensure positive leak control. Carefully dismantle piping that previously contained gas, gasoline, oil, or other dangerous fluids, with precautions taken to prevent injury to persons and property. Store piping outdoors until all fumes and residues are removed. Box prefabricated supports, hangers, plates, valves, and specialty items according to size and type. Wrap sprinkler heads individually in plastic bags before boxing. Classify piping not designated for salvage, or not reusable, as scrap metal.

3.1.18.3 Ducts

Classify removed duct work as scrap metal.

3.1.18.4 Fixtures, Motors and Machines

Remove and salvage fixtures, motors and machines associated with plumbing, heating, air conditioning, refrigeration, and other mechanical system installations. Salvage, box and store auxiliary units and accessories with the main motor and machines. Tag salvaged items for identification, storage, and protection from damage. Classify broken, damaged, or otherwise unserviceable units and not caused to be broken, damaged, or otherwise unserviceable as debris to be disposed of by the Contractor.

3.1.19 Electrical Equipment and Fixtures

Salvage motors, motor controllers, and operating and control equipment that are attached to the driven equipment. Salvage wiring systems and components. Box loose items and tag for identification. Disconnect primary, secondary, control, communication, and signal circuits at the point of attachment to their distribution system.

3.1.19.1 Fixtures

Remove and salvage electrical fixtures. Salvage unprotected glassware from the fixture and salvage separately. Salvage incandescent, mercury-vapor, and fluorescent lamps and fluorescent ballasts manufactured prior to 1978, boxed and tagged for identification, and protected from breakage.

3.1.19.2 Electrical Devices

Remove and salvage switches, switchgear, transformers, conductors including wire and nonmetallic sheathed and flexible armored cable, regulators, meters, instruments, plates, circuit breakers, panelboards, outlet boxes, and similar items. Box and tag these items for identification according to type and size.

3.1.19.3 Wiring Ducts or Troughs

Remove and salvage wiring ducts or troughs. Dismantle plug-in ducts and wiring troughs into unit lengths. Remove plug-in or disconnecting devices from the busway and store separately.

3.1.19.4 Conduit and Miscellaneous Items

Salvage conduit except where embedded in concrete or masonry. Consider corroded, bent, or damaged conduit as scrap metal. Sort straight and undamaged lengths of conduit according to size and type. Classify supports, knobs, tubes, cleats, and straps as debris to be removed and disposed.

3.1.20 Elevators and Hoists

Remove elevators, hoists, and similar conveying equipment and salvage as whole units, to the most practical extent. Remove and prepare items for salvage without damage to any of the various parts. Salvage and store rails for structural steel with the equipment as an integral part of the unit.

3.2 CONCURRENT EARTH-MOVING OPERATIONS

Do not begin excavation, filling, and other earth-moving operations that are sequential to demolition or deconstruction work in areas occupied by structures to be demolished or deconstructed until all demolition and deconstruction in the area has been completed and debris removed. Fill holes, open basements and other hazardous openings.

3.3 DISPOSITION OF MATERIAL

3.3.1 Title to Materials

Except for salvaged items specified in related Sections, and for materials or equipment scheduled for salvage, all materials and equipment removed and not reused or salvaged, shall become the property of the Contractor and shall be removed from Government property. Title to materials resulting from demolition and deconstruction, and materials and equipment to be removed, is vested in the Contractor upon approval by the Contracting Officer of the Contractor's demolition, deconstruction, and removal procedures, and authorization by the Contracting Officer to begin demolition and deconstruction. The Government will not be responsible for the condition or loss of, or damage to, such property after contract award. Showing for sale or selling materials and equipment on site is prohibited.

3.3.2 Reuse of Materials and Equipment

Remove and store materials and equipment listed in the Demolition and Deconstruction Plan indicated to be reused or relocated to prevent damage, and reinstall as the work progresses.

3.3.3 Salvaged Materials and Equipment

Remove materials and equipment that are indicated to be removed by the Contractor and that are to remain the property of the Government, and deliver to a storage site, as directed, within 25 km (15 miles) of the work site.

a. Salvage items and material to the maximum extent possible.

b. Store all materials salvaged for the Contractor as approved by the Contracting Officer and remove from Government property before completion of the contract. On site sales of salvaged material is prohibited.

c. Remove salvaged items to remain the property of the Government in a manner to prevent damage, and packed or crated to protect the items from damage while in storage or during shipment. Items damaged during removal or storage must be repaired or replaced to match existing items. Properly identify the contents of containers.

d. Remove historical items in a manner to prevent damage. Deliver the following historical items to the Government for disposition: Corner stones, contents of corner stones, and document boxes wherever located on the site.

3.3.4 Disposal of Ozone Depleting Substance (ODS)

Class I and Class II ODS are defined in Section, 602(a) and (b), of The Clean Air Act. Prevent discharge of Class I and Class II ODS to the atmosphere. Place recovered ODS in cylinders meeting AHRI Guideline K suitable for the type ODS (filled to no more than 80 percent capacity) and provide appropriate labeling. Recovered ODS shall be removed from Government property and disposed of in accordance with 40 CFR 82. Products, equipment and appliances containing ODS in a sealed, self-contained system (e.g. residential refrigerators and window air conditioners) shall be disposed of in accordance with 40 CFR 82. Submit Receipts or bills of lading, as specified. Submit a shipping receipt or bill of lading for all containers of ozone depleting substance (ODS) shipped to the Defense Depot, Richmond, Virginia.

3.3.4.1 Special Instructions

No more than one type of ODS is permitted in each container. A warning/hazardous label shall be applied to the containers in accordance with Department of Transportation regulations. All cylinders including but not limited to fire extinguishers, spheres, or canisters containing an ODS shall have a tag with the following information:

a. Activity name and unit identification code

b. Activity point of contact and phone number

c. Type of ODS and pounds of ODS contained

d. Date of shipment

e. Naval stock number (for information, call (804) 279-4525).

3.3.4.2 Fire Suppression Containers

Deactivate fire suppression system cylinders and canisters with electrical charges or initiators prior to shipment. Also, safety caps must be used to cover exposed actuation mechanisms and discharge ports on these special cylinders.

3.3.5 Transportation Guidance

Ship all ODS containers in accordance with MIL-STD-129, DLA 4145.25 (also referenced one of the following: Army Regulation 700-68, Naval Supply Instruction 4440.128C, Marine Corps Order 10330.2C, and Air Force Regulation 67-12), 49 CFR 173.301, and DOD 4000.25-1-M.

3.3.6 Unsalvageable and Non-Recyclable Material

Dispose of unsalvageable and non-recyclable combustible material outside the limits of the Government property (military installation) at the Contractor's responsibility and expense.

3.4 CLEANUP

Remove debris and rubbish from basement and similar excavations. Remove and transport the debris in a manner that prevents spillage on streets or adjacent areas. Apply local regulations regarding hauling and disposal.

3.5 DISPOSAL OF REMOVED MATERIALS

3.5.1 Regulation of Removed Materials

Dispose of debris, rubbish, scrap, and other nonsalvageable materials resulting from removal operations with ROK laws Act No. 10911, PD No. 22889, and MD No. 406. Storage of removed materials on the project site is prohibited. Report on the Generated Waste of Disposal of Removed Materials thru All baro System linked to http:\\www.wms-net.or.kr/index.jsp

3.5.2 Burning on Government Property

Burning of materials removed from demolished and deconstructed structures will not be permitted on Government property.

3.5.3 Removal to Spoil Areas on Government Property

Transport noncombustible materials removed from demolition and deconstruction structures to designated spoil areas on Government property.

3.5.4 Removal from Government Property

Transport waste materials removed from demolished and deconstructed structures, except waste soil, from Government property for legal disposal. Dispose of waste soil as directed.

3.6 REUSE OF SALVAGED ITEMS

Recondition salvaged materials and equipment designated for reuse before installation. Replace items damaged during removal and salvage operations or restore them as necessary to usable condition.

-- End of Section --

SECTION 02 61 13

EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5434	(2012) Field Logging of Subsurface Explorations of Soil and Rock
ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2302	(2002) Test Method for Particle Size Distribution of Soils
KS F 2303	(2000) Test Method for Liquid Limit and Plastic Limit of Soils

KS F 2311	(2001) Test Method for Soil Density by the Sand Replacement Method
KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F 2324	(2006) Method of Classification of Soils for Engineering Purposes
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method

REPUBLIC OF KOREA (ROK) LAW

Act No. 11998	(6 Aug 2013) Korean Waste Management Act (WMA)
PD No. 24543	(28 May 2013) Korean Presidential Decree (PD) of WMA
MD No. 513	(20 Jul 2012) Korean Ministry of Environment, Ministerial Decree (MD) of WMA

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926	Safety and Health Regulations for Construction
40 CFR 302	Designation, Reportable Quantities, and Notification

1.2 DESCRIPTION OF WORK

The work shall consist of excavation and temporary storage of contaminated material as indicated on the drawings. Approximate locations of contaminated material are shown on the drawings. Chemical analysis of contaminated material has been performed by the Government. Subsurface conditions are shown on the drawings. The Contractor shall submit a Work Plan as specified in the Submittals paragraph. The Contracting Officer shall be notified within 48 hours, if contaminated material is discovered that has not been previously identified or if other discrepancies between data provided and actual field conditions are discovered. Backfill material is not available on-site.

1.2.1 Scheduling

Notify the Contracting Officer 7 calendar days prior to the start of excavation of contaminated material. The Contractor shall be responsible for contacting regulatory agencies in accordance with the applicable reporting requirements.

1.2.2 Work Plan

Submit a Work Plan within 30 calendar days after notice to proceed. No work at the site, with the exception of site inspections and surveys, shall be performed until the Work Plan is approved. Allow 30 calendar days in the schedule for the Government's review. No adjustment for time or money will be made if resubmittals of the Work Plan are required due to deficiencies in the plan. At a minimum, the Work Plan shall include:

a. Schedule of activities.

b. Method of excavation and equipment to be used.

c. Shoring or side-wall slopes proposed.

d. Dewatering plan.

e. Storage methods and locations for liquid and solid contaminated material.

f. Borrow sources and haul routes.

g. Decontamination procedures.

h. Spill contingency plan.

1.2.3 Other Submittal Requirements

Submit separate cross-sections of each area before and after excavation and after backfilling, test results, and one hard copy & one digital copy (.pdf - text searchable) of the Closure Report within 14 calendar days of work completion at the site.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Surveys; G

SD-03 Product Data

Work Plan; G
Closure Report; G

SD-06 Test Reports

Backfill; G
Surveys; G
Confirmation Sampling and Analysis; G
Sampling of Stored Material; G
Sampling Liquid; G
Compaction; G

1.4 REGULATORY REQUIREMENTS

1.4.1 Permits and Licenses

Obtain required federal, state, and local permits for excavation and storage of contaminated material. Permits shall be obtained at no additional cost to the Government.

1.4.2 Air Emissions

Air emissions shall be monitored and controlled in accordance with Section 01 57 20.00 10 ENVIRONMENTAL PROTECTION.

PART 2 PRODUCTS

2.1 SPILL RESPONSE MATERIALS

Provide appropriate spill response materials including, but not limited to the following: containers, adsorbents, shovels, and personal protective equipment. Spill response materials shall be available at all times when contaminated materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of materials and contaminants being handled.

2.2 BACKFILL

Backfill material shall be obtained from offsite sources approved by the Contracting Officer. Backfill shall be classified in accordance with ASTM D2487 or KS F 2324 as GW, GP, GM, GC, SW, SP, SM, SC, ML, MH, CL, or CH and shall be free from roots and other organic matter, trash, debris, snow, ice or frozen materials. Backfill material shall be tested for the parameters listed below at a frequency of once per 3000 cubic meters (3900 cubic yards). A minimum of one set of classification tests shall be performed per borrow source. One backfill sample per borrow source shall also be collected and tested for the chemical parameters listed below.

Physical Parameter	Test Method
Grain Size	ASTM D422 or KS F 2302
Compaction	ASTM D1557 or KS F 2312
Atterberg Limit	ASTM D4318 or KS F 2303

Chemical Parameter	Criteria
TPH for Diesel Fuel Oil #2	1000 PPM
BTEX for Gasoline	100 PPM

Do not use material for backfill until borrow source chemical and physical test results have been submitted and approved.

Offsite soils brought in for use as backfill shall be tested for Total Petroleum Hydrocarbons (TPH) and Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX). Backfill shall contain less than 100 parts per million (ppm) TPH, less than 1 ppm Benzene, less than 20 ppm Toluene, less than 50 ppm Ethyl Benzene, and less than 15 ppm Xylene. Determine TPH concentrations by using EPA SW-846.3-3 Method 8015. Determine BTEX concentrations by using EPA SW-846.3-3 Method 8021 or 8260.

Provide borrow site testing for TPH and BTEX from composite samples of soil collected from the borrow site, with the composite samples being representative of the soil to be acquired for the project. Surface samples shall be obtained by excavating a minimum of 20 centimeters (4 inches) from the surface. For borrow sites 8100 square meters (2 acres) or less, 1 composite sample shall be collected from the site for analysis. For borrow sites larger than 8100 square meters (2 acres), 1 sample for each additional 8100 square meter (2 acre) increment shall be collected. For borrow excavations deeper than 2 meters (6 feet), the above sampling protocol shall be repeated again with every 2 meter (6 foot) increase in depth.

For each prospective borrow site, the contractor shall submit to the Contracting Officer a Borrow Site Environmental Assessment Report which documents that borrow soil from the site is not contaminated. The Borrow Site Environmental Assessment Report shall include the following: general site description and environmental condition; location information and map; historic and current land use; photographs; any known contaminant spills in the area; any on-site or adjacent facilities which pose risks of contaminating the borrow fill; procedures for soil sample collection and collection locations; and the laboratory testing procedures and resulting analytical data. The report shall have a cover sheet that is signed by the contractor, which attests and certifies the suitability of the fill material. Soil from a particular borrow site shall not be brought onsite until this report has been approved by the Contracting Officer.

PART 3 EXECUTION

3.1 SURVEYS

Surveys shall be performed immediately prior to and after excavation of contaminated material to determine the volume of contaminated material removed. Surveys shall also be performed immediately after backfill of each excavation. Provide cross-sections on 7.6 meter (25 foot) intervals and at break points for all excavated areas. Locations of confirmation samples shall also be surveyed and shown on the drawings.

3.2 EXISTING STRUCTURES AND UTILITIES

No excavation shall be performed until site utilities have been field located. Take the necessary precautions to ensure no damage occurs to existing structures and utilities. Damage to existing structures and utilities resulting from the Contractor's operations shall be repaired at no additional cost to the Government. Utilities encountered that were not previously shown or otherwise located shall not be disturbed without approval from the Contracting Officer.

3.3 CLEARING

Clearing shall be performed to the limits shown on the drawings in accordance with Section 31 11 00 CLEARING AND GRUBBING.

3.4 CONTAMINATED MATERIAL REMOVAL

3.4.1 Excavation

Areas of contamination shall be excavated to the depth and extent shown on the drawings and not more than 60 mm (0.2 feet) beyond the depth and extent shown on the drawings unless directed by the Contracting Officer.

Excavation shall be performed in a manner that will limit spills and the potential for contaminated material to be mixed with uncontaminated material. An excavation log describing visible signs of contamination encountered shall be maintained for each area of excavation. Excavation logs shall be prepared in accordance with ASTM D5434.

3.4.2 Shoring

If workers must enter the excavation, it shall be evaluated, shored, sloped or braced as required by EM 385-1-1 and 29 CFR 1926 section 650.

3.4.3 Dewatering

Surface water shall be diverted to prevent entry into the excavation. Dewatering shall be limited to that necessary to assure adequate access, a safe excavation, prevent the spread of contamination, and to ensure that compaction requirements can be met.

3.5 CONFIRMATION SAMPLING AND ANALYSIS

The Contracting Officer shall be present to inspect the removal of contaminated material from each site. After all material suspected of being contaminated has been removed, the excavation shall be examined for evidence of contamination. If the excavation appears to be free of contamination, field analysis shall be used to determine the presence of volatile and/or semi-volatile contamination using a real time vapor monitoring instrument or Photo Ionization Detector (PID). Excavation of additional material shall be as directed by the Contracting Officer. After all suspected contaminated material is removed, confirmation samples shall be collected and analyzed for the following contaminant chemical parameters and action levels as indicated in the contract drawings & documents:

Chemical Parameter	Action Level
TPH	xxx PPM
BTEX	xxx PPM

Samples shall be collected at a frequency of one per 500 square meters (600 square yards) from the bottom and each of the side walls or as directed by the Contracting Officer. A minimum of one sample shall be collected from the bottom and each side wall of the excavation. Based on test results, propose any additional excavation which may be required to remove material which is contaminated above action levels. Additional excavation shall be subject to approval by the Contracting Officer. Locations of samples shall be marked in the field and documented on the as-built drawings.

3.6 CONTAMINATED MATERIAL STORAGE

Material shall be placed in temporary storage immediately after excavation. The following paragraphs describe acceptable methods of material storage. Storage units shall be in good condition and constructed of materials that are compatible with the material or liquid to be stored. If multiple storage units are required, each unit shall be clearly labeled with an identification number and a written log shall be kept to track the source of contaminated material in each temporary storage unit.

3.6.1 Stockpiles

Stockpiles shall be constructed to isolate stored contaminated material from the environment. The maximum stockpile size shall be 1000 cubic meters (1300 cubic yards). Stockpiles shall be constructed to include:

a. A chemically resistant geomembrane liner free of holes and other damage. Non-reinforced geomembrane liners shall have a minimum thickness of 0.5 mm (20 mils). Scrim reinforced geomembrane liners shall have a minimum weight of 20 kg/100 square meters (40 lbs/1000 square feet). The ground surface on which the geomembrane is to be placed shall be free of rocks greater than 13 mm (0.5 inches) in diameter and any other object which could damage the membrane.

b. Geomembrane cover free of holes or other damage to prevent precipitation from entering the stockpile. Non-reinforced geomembrane covers shall have a minimum thickness of 0.25 mm (10 mils). Scrim reinforced geomembrane covers shall have a minimum weight of 13 kg/100 square meters (26 lbs/1000 square feet). The cover material shall be extended over the berms and anchored or ballasted to prevent it from being removed or damaged by wind.

c. Berms surrounding the stockpile, a minimum of 300 mm (12 inches) in height. Vehicle access points shall also be bermed.

d. The liner system shall be sloped to allow collection of leachate. Storage and removal of liquid which collects in the stockpile, in accordance with paragraph Liquid Storage.

3.6.2 Roll-Off Units

Roll-off units used to temporarily store contaminated material shall be water tight. A cover shall be placed over the units to prevent precipitation from contacting the stored material. The units shall be located as directed by the Contracting Officer. Liquid which collects inside the units shall be removed and stored in accordance with paragraph Liquid Storage.

3.6.3 Liquid Storage

Liquid collected from excavations and stockpiles shall be temporarily stored in 220 Liter (55 gallon) barrels. Liquid storage containers shall be water-tight and shall be located as directed by the Contracting Officer.

3.7 SAMPLING

3.7.1 Sampling of Stored Material

Samples of stored material shall be collected at a frequency of once per 460 cubic meters (600 cubic yards). Samples shall be tested for the following chemical parameters and action levels as indicated in the contract drawings & documents:

Chemical Parameter	Action Level
TPH	xxx PPM
BTEX	xxx PPM

Stored material with contaminant levels that exceed the action levels shall be treated offsite. Analyses for contaminated material to be taken to an offsite treatment facility shall conform to local criteria as well as to the requirements of the treatment facility. Documentation of all analyses performed shall be furnished to the Contracting Officer. Additional sampling and analyses to the extent required by the approved offsite treatment, storage or disposal (TSD) facility shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

3.7.2 Sampling Liquid

Liquid collected from excavations, storage areas, and decontamination facilities shall be sampled at a frequency of once for every 2,000 L (500 gal) of liquid collected. Samples shall be tested for chemicals indicated in contract drawings & documents and the following chemicals :

Chemical Parameter	Action Level
TPH	xxx PPM
BTEX	xxx PPM

Liquid with contaminant levels that exceed action levels shall be treated offsite. Analyses for contaminated liquid to be taken to an offsite treatment facility shall conform to local, state, and federal criteria as well as to the requirements of the treatment facility. Documentation of all analyses performed shall be furnished to the Contracting Officer. Additional sampling and analysis to the extent required by the approved offsite treatment, storage or disposal (TSD) facility receiving the material shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

3.7.3 Sampling Beneath Storage Units

Samples from beneath each storage unit shall be collected prior to construction of and after removal of the storage unit. Samples shall be collected at a frequency of one per each 330 square meters (360 square yards) from a depth interval of 0 to 0.15 m (0 to 0.5 feet) and shall be tested for the chemicals indicated in contract drawings & documents and the following chemicals :

Chemical Parameter	Action Level
TPH	xxx PPM
BTEX	xxx PPM

Based on test results, soil which has become contaminated above action levels shall be removed at no additional cost to the Government. Contaminated material which is removed from beneath the storage unit shall be handled in accordance with paragraph Sampling of Stored Material. As directed by the Contracting Officer and at no additional cost to the Government, additional sampling and testing shall be performed to verify areas of contamination found beneath stockpiles have been cleaned up to below action levels.

3.8 SPILLS

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), pollutant, contaminant, or oil (as governed by the Oil Pollution Act (OPA), 33 U.S.C. 2701 et seq.), notify the Contracting

Officer immediately. If the spill exceeds the reporting threshold, follow the pre-established procedures as described in the Base Wide Contingency Plan for immediate reporting and containment. Immediate containment actions shall be taken to minimize the effect of any spill or leak. Cleanup shall be in accordance with applicable federal, state, and local regulations. As directed by the Contracting Officer, additional sampling and testing shall be performed to verify spills have been cleaned up. Spill cleanup and testing shall be done at no additional cost to the Government.

3.9 BACKFILLING

3.9.1 Confirmation Test Results

Excavations shall be backfilled immediately after all contaminated materials have been removed and confirmation test results have been approved. Backfill shall be placed and compacted to the lines and grades shown on the drawings.

3.9.2 Compaction

Approved backfill shall be placed in lifts with a maximum loose thickness of 200 mm (8 inches). Soil shall be compacted to 90 percent of ASTM D698, ASTM D1557, or KS F 2312 maximum dry density. Density tests shall be performed at a frequency of once per 930 square meters (10000 square feet) per lift. A minimum of one density test shall be performed on each lift of backfill placed. Field in-place dry density shall be determined in accordance with ASTM D1556, ASTM D2167, KS F 2311, or KS F 2347.

3.10 DISPOSAL REQUIREMENTS

Offsite disposal of contaminated material shall be in accordance with all applicable ROK laws Act No. 11998, PD No. 24543, and MD No. 513.

3.11 CLOSURE REPORT

One hard copy & one digital copy (.pdf - text searchable) of a Closure Report shall be prepared and submitted within 30 calendar days of completing work at each site included in a contract or project. The report shall be indexed, bookmarked, and labeled with the contract number, project name, location, date, name of general Contractor, and the Government Office contracting for the work. The Closure Report shall include the following information as a minimum:

a. A cover letter signed by a responsible company official or registered Professional Engineer certifying that all services involved have been performed in accordance with the terms and conditions of the contract documents and regulatory requirements.

b. A narrative report including, but not limited to, the following:

    (1) site conditions, ground water elevation, and cleanup criteria;

    (2) excavation logs;

    (3) field screening readings;

    (4) quantity of materials removed from each area of contamination;

(5) quantity of water/product removed during dewatering;

(6) sampling locations and sampling methods;

(7) sample collection data such as time of collection and method of preservation;

(8) sample chain-of-custody forms; and

(9) source of backfill.

c. Copies of all chemical and physical test results.

d. Copies of all manifests and land disposal restriction notifications.

e. Copies of all certifications of final disposal signed by the responsible disposal facility official.

f. Waste profile sheets.

g. Scale drawings showing limits of each excavation, limits of contamination, known underground utilities within 15 meters (50 feet) of excavation, sample locations, and sample identification numbers. On-site stockpile, storage, treatment, loading, and disposal areas shall also be shown on the drawings.

h. Progress Photographs. Color photographs shall be used to document progress of the work. A minimum of four views of the site showing the location of the area of contamination, entrance/exit road, and any other notable site conditions shall be taken before work begins. After work has been started, activities at each work location shall be photographically recorded daily, unless otherwise indicated in project/contract documents. Photographs shall be digital, 1600x1200x24 bit true color, 8 megapixel minimum resolution in JPEG file format:

(1) Soil removal and sampling.

(2) Dewatering operations.

(3) Unanticipated events such as spills and the discovery of additional contaminated material.

(4) Contaminated material/water storage, handling, treatment, and transport.

(5) Site or task-specific employee respiratory and personal protection.

(6) Fill placement and grading.

(7) Post-construction photographs. After completion of work at each site, take a minimum of four views of each excavation site.

A digital version of all photos shown in the report shall be included with the Closure Report. Provide digital photographs for the hard copy of the closure report on a separate CD-R, cumulative of all photos to date. Photographs shall be digital, 1600x1200x24 bit true color, 8 megapixel minimum resolution in JPEG file format. Each photograph shall have an information box associated with it. The box shall be typewritten and arranged as follows:

Project Name:	Direction of View:
Location:	Date/Time:
Photograph No.:	Description of View:

-- End of Section --

SECTION 02 65 00

UNDERGROUND STORAGE TANK REMOVAL
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API PUBL 1628	(1996) A Guide to the Assessment and Remediation of Underground Petroleum Releases
API RP 1604	(1996; R 2001) Closure of Underground Petroleum Storage Tanks
API RP 2003	(2008; 7th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 2219	(2005) Safe Operation of Vacuum Trucks in Petroleum Service
API STD 2217A	(2009) Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries
API Std 2015	(2001; R 2006) Safe Entry and Cleaning of Petroleum Storage Tanks

ASTM INTERNATIONAL (ASTM)

ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4397	(2010) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D6938	(2010) Standard Test Method for In-Place

	Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2324	(2006) Method of Classification of Soils for Engineering Purposes
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-1-4006	(1998) Engineering and Design -- Removal of Underground Storage Tanks (USTs)
EM 200-1-1	(1994) Environmental Quality -- Validation of Analytical Chemistry Laboratories
EM 200-1-3	(2001) Engineering and Design -- Requirements for the Preparation of Sampling and Analysis Plans
EM 200-1-6	(1997) Environmental Quality -- Chemical Quality Assurance for HTRW Projects
EM 200-1-7	(2001) Environmental Quality - Performance Evaluation (PE) Program
EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530-R-97-007	(1997) Best Management Practices (BMPs) for Soils Treatment Technologies; Suggested Operational Guidelines to Prevent Cross-Media Transfer of Contaminants During Cleanup Activities
EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846	(Third Edition; Update IV) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste

40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 268	Land Disposal Restrictions
40 CFR 279	Standards for the Management of Used Oil
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

1.2 SYSTEM DESCRIPTION

The work consists of removal, decontamination and disposal of underground storage tanks and associated piping and ancillary equipment, including but not limited to dewatering (if approved), disposal of contaminated soil, providing reports which are required by regulatory agencies, and backfilling. The tanks are constructed of steel or fiberglass and are at the location indicated on the drawings. The tank was used for storing fuel oil. Residue remaining in the tank is considered a hazardous waste. Verify the actual conditions prior to submitting a bid. Treat the site as a hazardous waste site. The site is not a hazardous waste site, but due to the nature of the materials and hazards present, use specified procedures until closure activities are complete.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Work Plan; G
Site safety and health plan; G
Excavation and material handling plan; G
Field sampling and laboratory testing plan; G
Tank and piping removal and disposal plan; G
Spill and discharge control plan; G
Qualifications; G
Laboratory Services; G

SD-06 Test Reports

Backfill Material; G.
Tank Contents Verification; G.
Contaminated Water Disposal; G.
Soil Examination, Testing, and Analysis; G.
Backfilling; G.
Tank Closure Report; G.

SD-11 Closeout Submittals

Salvage Rights; G
Tank Closure Report; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Substantiate a minimum of 2 years of tank removal experience Experience shall include removal, transportation, and disposal of underground tanks and associated piping, in conformance with the following:

a. API RP 1604

b. 40 CFR 280, and ROK national, provincial, and local regulations and procedures.

c. Applicable safety rules and regulations.

d. Use of equipment and procedures for testing and vapor-freeing tanks.

e. Handling and disposal of types of wastes encountered in underground tank and pipe removal including disposal of underground tanks and associated piping.

f. Excavation, testing, and disposal of petroleum contaminated soils, liquids, and sludge.

g. Project titles, dates performed, owner's names, points of contact for each project with current contact phone numbers.

1.4.2 Laboratory Services

Submit documentation for laboratory services in accordance with EM 1110-1-4006, EM 200-1-1, EM 200-1-3, EM 200-1-6, and EM 200-1-7.

1.4.3 Support Staff

Identify all staff involved for the various components, including personnel collecting and shipping samples, and detail staff member's qualifications.

1.4.4 Preconstruction Conference and Work Plan

Prior to the commencement of work, a preconstruction conference will be scheduled by the Contracting Officer. Prepare and submit a comprehensive Work Plan within 30 days of contract award. The work plan shall conform to the requirements of this specification, API RP 1604, API Std 2015, API RP 2003, API STD 2217A and API RP 2219. Allow 30days in the schedule for the Government's review and approval. No adjustment for time or money will be made for re-submittals required as a result of noncompliance. No work at the site is allowed, with the exception of site inspections and mobilization, until the Work Plan is approved. As a minimum, include the following in the Work Plan:

1.4.4.1 Site Safety and Health Plan

Furnish detailed safety, health, and accident prevention provisions and develop a Site Safety and Health Plan (SSHP). Incorporate the requirements of 29 CFR 1910 and EM 385-1-1 into the SSHP. Include current training certification statement for personnel prior to entry into the work site. Do not commence work until the SSHP is approved by the Contracting Officer. As a minimum, include the following:

a. Health and safety organization, including discussion of distribution of functions and responsibilities.

b. Organization and components of the SSHP.

c. Physical and chemical site hazard identification.

d. Basic toxicology and toxicity information.

e. Discussion of the EZ and CRZ.

f. Protective clothing.

g. Respiratory protection.

h. Air quality monitoring.

i. Personnel exposure guidelines.

j. Decontamination procedures.

k. Basic first aid review.

l. Emergency response and contingency plan.

m. Site entry and exit procedures.

n. Sampling procedures.

1.4.4.2 Excavation and Material Handling Plan

Describe methods, means, equipment, sequence of operations and schedule to be employed in excavation, transport, handling, borrowing source and stockpiling of soil during underground tank removal. Include shoring requirements. Fifteen days before beginning tank removal work, submit to the Contracting Officer, for approval, a material handling plan that describes phases of dealing with the contaminated soil and water as it relates to the proposed tanks and piping removal, including methods of excavating, a material handling plan for the contaminated material, soil testing requirements, and water pumping and collection requirements.

1.4.4.3 Field Sampling and Laboratory Testing Plan

Describe field sampling methods and quality control procedures. Identify laboratory and laboratory methods to be used for contamination testing. Include sample reports showing sample identification for location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, and quality control procedures.

1.4.4.4 Tank and Piping Removal and Disposal Plan

Describe methods, means, sequence of operations, and schedule to be employed in the testing, pumping, cleaning, de-vaporizing, inspecting, cutting and removal, and disposal of underground storage tanks and piping. Include methods to be employed for product, sludge, vapor, and pumpable liquid removal; purging and inerting; and storage methods proposed for control of surface water. Also address the following:

a. Treatment Options
b. Identification of waste, tank and contaminated soil transporters and means of transport.
c. Disposal and alternate facilities, disposal or remediation.
d. Decontamination procedures and coordination with SSHP.

Coordinate decontamination procedures, shoring, and safety measures in accordance with Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES.

1.4.4.5 Spill and Discharge Control Plan

Develop a comprehensive spill and discharge control plan. Consider and provide contingency measures for potential spills and discharges from handling and transportation of contaminated soils and water. A possible source of guidance for assessment and remediation is API PUBL 1628.

1.4.4.6 Site Safety And Health Officer

Identify an individual to serve as the Site Safety and Health Officer (SSHO) to report problems and concerns regarding health and safety to the Contracting Officer. Provide documentation that the SSHO possesses working knowledge of local and Federal occupational safety and health regulations, and provide training, in accordance with 29 CFR 1910 to Contractor employees in air monitoring practices and techniques. The SSHO shall remain onsite to provide day to day industrial hygiene support, including air monitoring, training, and daily site safety inspections. The SSHO may be assigned other duties, such as project foreman or quality control manager.

1.4.5 Permits and Licenses

As required or as directed by the Contracting Officer, obtain local permits and licenses that directly impact the Contractor's ability to perform the work prior to commencing removal operations.

1.4.6 Statutes and Regulations

Perform tank closures, removal, and disposal in accordance with 40 CFR 280, 40 CFR 262, 40 CFR 264, and 40 CFR 265. Transport hazardous material waste in accordance with Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS.

1.5 PROJECT/SITE CONDITIONS

Notify the Installation Environmental Coordinator (IEC) and the Contracting Officer 30 days prior to tank removal. The IEC will be responsible for contacting the Implementation Agency (IA)in accordance with the applicable reporting requirements.

PART 2 PRODUCTS

2.1 BACKFILL MATERIAL

Obtain backfill material from the location indicated on the drawings or offsite as required by contract, delivery order, or task order.. Classify backfill in accordance with ASTM D2487, or KS F 2324 as GW, GP, GM, GC, SW, SP, SM, SC, MH, CL, or CH and free from roots and other organic matter, trash, debris, snow, ice or frozen materials. Secure and submit approved soil classification test results, including the chain-of-custody records, prior to bringing offsite materials onsite. The testing frequency for backfill material is 5 samples per 500 cubic meters (yards) or a minimum of 1 test. Contractor shall create a composite sample from 5 samples taken and submit for laboratory analysis. Use non-contaminated material removed from the excavation for backfill in accordance with Paragraph BACKFILLING.

2.2 PLASTIC SHEETING

Provide plastic sheeting conforming to ASTM D4397.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Furnish labor, materials, necessary permits, laboratory tests, and reports and equipment to remove and dispose of products remaining in the underground tanks; clean and vapor free the underground tanks and connecting piping; excavate, remove underground tanks and associated piping, and backfill to the level of the adjacent ground; sample soil and water to determine if contaminated; dispose of tanks and associated piping, and petroleum contaminated soil and water.

3.1.1 Safety Guidelines

Comply with personnel safety guidelines specified in Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES, and conform to the guidelines as stipulated in the approved SSHP.

3.1.2 Exclusion Zone (EZ) And Contamination Reduction Zone (CRZ)

Do not permit personnel, not directly involved with the project, to enter work zones, called the EZ and CRZ. The EZ is an area around the tank a minimum of 3 m (10 feet) from the limits of the tank excavation. At the perimeter of the EZ, establish a CRZ. Clean equipment and personnel within the CRZ, as stated in the paragraph titled "Personnel and Equipment Decontamination." Locate the Contractor's site office, parking area, and other support facilities outside the EZ and CRZ. Clearly mark and post boundaries of the EZ and CRZ. Include a site map, outlining the extent of work zones and location of support facilities, in the SSHP.

3.1.3 Onsite Training

Prior to starting onsite work, conduct a health and safety training class directed by the SSHO to discuss the implementation of the SSHP. Notify the Contracting Officer 24 hours prior to beginning the training class.

3.1.4 Personnel Protection

Furnish appropriate personal safety equipment and protective clothing to personnel and ensure that safety equipment and protective clothing is kept clean and well maintained. Furnish three clean sets of personal protective equipment and clothing for use by the Contracting Officer or official visitors as required for entry into the EZ.

3.1.5 Respiratory Protection Program

Fully employ respiratory protection program, addressing respirator usage and training, in accordance with 29 CFR 1910 and EM 385-1-1.

3.1.6 Decontamination

Decontaminate or properly dispose of personal protective equipment and clothing worn in contaminated areas at the end of the work day. The SSHO is responsible for ensuring that personal protective clothing and equipment are decontaminated before being reissued.

3.1.7 Emergency Response and First Aid Equipment

a. Prior to commencement of work, thoroughly review emergency response and contingency plan in accordance with 29 CFR 1910. In an emergency, take action to remove or minimize the cause of the emergency, alert the Contracting Officer, and institute necessary measures to prevent repetition of the emergency. Equip site-support vehicles with route maps providing directions to the medical treatment facility.

b. Provide appropriate emergency first aid equipment for treatment of exposure to site physical and chemical hazards. Provide and post a list of emergency phone numbers and points of contact for fire, hospital, police, ambulance, and other necessary contacts. Provide and post a route map detailing the directions to the nearest medical facility.

c. Notify the Contracting Officer of any unforeseen hazard or condition which becomes evident during work.

3.1.8 Burning and Explosives

Use of explosives or burning debris is not allowed. Do not permit ignition sources in the EZ and CRZ.

3.1.9 Protection of Existing Structures and Utilities

Take all necessary precautions to avoid damage to existing structures, their appurtenances, monitoring wells, or utilities that may be affected by work activities. Repair any damage to utilities or monitoring wells resulting from the Contractor's operations at no expense to the Government. Coordinate with the installation to locate underground utilities prior to beginning construction. Do not disturb utilities encountered which were not previously shown or otherwise located without approval from the Contracting Officer.

3.1.10 Shoring

Provide shoring in accordance with Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES.

3.2 TANK CONTENTS VERIFICATION

Conduct sampling and analysis in accordance with the approved Sampling and Analysis Plan. Submit reports, including the chain-of-custody records.

3.2.1 Sampling

Sample tank product, pumpable liquids, tank coatings and sludge. If the data is not adequate, additional sampling and analysis to the extent required by the approved offsite facility receiving the material is the responsibility of the Contractor. Meeting all regulatory requirements, including the preparation of hazardous materials and waste for transportation, is the responsibility of the Contractor.

3.2.2 Analysis

Contractor shall test tank contents for the parameters listed herein. Include total petroleum hydrocarbons (TPH) benzene, ethyl benzene, toluene and xylene (BETX), TPH Diesel Range Organics (DRO), Gasoline Range Organics (GRO), and lead in the analysis.

3.2.3 Characterization

Prior to removing any of the tank contents, characterize the contents to determine the type of required disposal: as a hazardous special waste based on ROK national, provincial, and local disposal regulations. Characterize tank product, pumpable liquids, and sludge in accordance with 40 CFR 261 and 40 CFR 279. Submit the waste contents determination and accompanying test results for each phase present in the tank to the Contracting Officer. The Contractor is responsible for any additional requirements identified by the disposal facility. Do not remove the tank contents until approval is given by the Contracting Officer.

3.3 CLEARING, GRUBBING AND REMOVALS

Perform clearing and grubbing in accordance with Section 31 11 00 CLEARING AND GRUBBING.

3.4 TOPSOIL

Topsoil shall meet the requirements in Section 31 00 00 EARTHWORK.Strip and stockpile uncontaminated topsoil separately for reuse at a location approved by the Contracting Officer if it meets the requirements of clean fill given in Paragraph BACKFILLING. Obtain additional topsoil in excess of that produced by excavation offsite, unless otherwise indicated . Cover with topsoil all areas disturbed by tank removal operations, other than areas to receive pavement or similar surface under this contract.

3.5 PREPARATIONS FOR EXCAVATION

Before excavating, remove residual liquids trapped in the product lines and remove all product from the tank. Purge and vent the tank in accordance with API RP 1604, and as specified herein.

3.5.1 Removal of Product, Pumpable Liquids, and Sludge

Contain and store tank product, pumpable liquids, and sludge onsite, prior to disposal. Treat contaminated water as specified. Analyze and segregate tank product, pumpable liquids, and sludge to recover reusable products prior to being transported to the designated location . Remove and dispose of tank product, pumpable liquids, and sludge. Use of Government facilities for permanent storage or disposal of the wastes is prohibited. Temporary storage on Government facilities will be allowed only until testing is complete, manifests (if necessary) are complete, and transportation is arranged. The Contractor is responsible for obtaining all required permits. Usable product shall be the property of the Contractor. Provide approved containers, vehicles, equipment, labor, signs, labels, placards and manifests and associated land disposal restriction notices and notifications, necessary for accomplishment of the work, including materials necessary for cleaning up spills that could occur from tank removal operations.

3.5.2 Contaminated Water Disposal

3.5.2.1 Sampling, Analysis, and Containment

Sample and analyze contaminated water both prior to and after treatment. Analyze contaminated water produced from excavation operations and tank pumping treated onsite, for pH; benzene, ethyl benzene, toluene, and xylene (BETX); total lead; oil and grease; and total petroleum hydrocarbons (TPH). Perform sampling and analysis prior to disposal for every 200,000 L (50,000 gallons) of contaminated water treated. Conform analysis of contaminated water to be taken to an offsite treatment facility to the requirements of the treatment facility, with documentation of all analyses performed furnished to the Contracting Officer in accordance with paragraph RECORDS. Contain, store onsite, and analyze contaminated water and dispose of in accordance with applicable Federal and state disposal regulations. Provide approved containers, vehicles, equipment, labor, signs, labels, placards and manifests and associated land disposal notices and notifications, necessary for accomplishment of the work.

3.5.2.2 Treatment

Treat contaminated water offsite by oil water separation, or other means as approved by the Contracting Officer. If contaminated water is to be treated onsite, specify the proposed treatment in the Work Plan and submit for approval, including the chain-of-custody records. Install temporary storage and treatment equipment in the general vicinity of the tanks at a location approved by the Contracting Officer. Sample and analyze treated effluent and secure approval of results by the Contracting Officer before discharge to the sanitary sewer . Treat and discharge effluent in accordance with the discharge permit.

3.6 PURGING AND INERTING

After the tank and piping contents have been removed, but prior to excavation beyond the top of the tank, disconnect all the piping (except the piping needed to purge or inert the tank). Purge flammable and toxic vapors from the tank or make the tank inert in accordance with API RP 1604, with the exception that filling with water is not permitted and, if dry ice is employed, use a minimum of 1.8 kg per 500 L (3 pounds per 100 gallons) of tank volume. Continuously monitor the tank atmosphere for combustible vapors if the tank is purged, or continuously monitor for oxygen, if the tank is inerted.

3.7 EXCAVATION

Mark all excavation areas, as well as work near roadways, in accordance with SITE SAFETY AND HEALTH PLAN (SSHP).

3.7.1 Exploratory Trenches

Excavate exploratory trenches as necessary to determine the tank location, limits and the location of ancillary equipment. Upon commencing exploratory excavation, utilize organic vapor analyzer/flame ionization device (OVA/FID) equipment to obtain readings for total petroleum hydrocarbons (TPH), and benzene, toluene, ethyl benzene, and xylene (BTX), and toxicity characteristic leaching procedure (TCLP). If BTEX indicates gasoline, then provide TCLP.

3.7.2 Tank Excavation

a. Provide Contracting Officer with written documentation, no later than 30 days before work begins, that proper ROK authorities have been notified. Notify the Contracting Officer at least 48 hours prior to start of tank removal work. Stage operations to minimize the time that tank excavation is open and the time that contaminated soil is exposed to the weather. Provide protection measures around the excavation area to prevent water runoff and to contain the soil within the excavation area.

b. Perform excavation around the perimeter of the tank to limit the amount of potentially petroleum contaminated soil that could be mixed with previously uncontaminated soil. Segregate petroleum contaminated soil in separate stockpiles.

c. Maintain an excavation around the tank of sufficient size to allow workers ample room to complete the work, but also protect the workers from sliding or cave-ins. Install sheeting, bracing, or shoring in the absence of adequate side slopes if there is a need for workers to enter the excavated area. Divert surface water to prevent direct entry into the excavation.

d. Collect and test water generated by dewatering during excavation required for removal of tanks or piping, surface water collected in open excavation, or water used for washing equipment or existing concrete or bituminous surfaces, in accordance with EPA 530-R-97-007, EPA 600/4-79/020, EPA SW-846 and state or locally required analyses.

3.7.3 Temporary Containment of Excavated Soil

Provide temporary containment area near the excavated area. Cover containment area with 0.75 mm (30 mil) polyethylene sheeting. Place excavated soil on the impervious barrier and cover with 0.15 mm (6 mil) polyethylene sheeting. Provide straw bale berm around the outer limits of the containment area and cover with polyethylene sheets. Secure edges of sheets to keep the polyethylene sheeting in place.

3.7.4 Piping Excavation

Perform excavation as necessary to remove tank piping and ancillary equipment in accordance with paragraphs: Shoring, Tank Excavation, and Open Excavations.

3.7.5 Open Excavations

Secure open excavations and stockpile areas while awaiting confirmation test results from the soil beneath the tank. Backfill the excavation as soon as possible after tank and contaminated soil removals have been completed and confirmation samples have been taken. Divert surface water around excavations to prevent water from directly entering into the excavation.

3.7.6 Hidden Structures

During excavation activities, if asphalt pavement, concrete slabs, or other hidden structures are encountered, remove and wash with high pressure water cleaning equipment. Remove and dispose of the pavement, concrete, and other structures as specified in Section 02 41 00 DEMOLITION.

3.7.7 Stockpiles

Uncontaminated excavated soil and petroleum contaminated soil, that is not a regulated hazardous waste, shall be stockpiled and used for backfill in the tank excavation prior to using borrow material. Excavated material that is regulated as a hazardous waste which is visibly stained, for which real time vapor monitoring instrument readings exceed 20 ppm for volatile and possibly semi-volatile hydrocarbons depending on the performance criteria for the field screening method, and which has an obvious petroleum odor is considered contaminated. Place in containers such as drums, roll-offs or dumpsters for sampling in accordance with paragraph Stockpiled Material Sampling. Separately stockpile uncontaminated soil from the contaminated soil, a safe distance away from, but adjacent to, the excavation. Place allowable stockpiles of contaminated soil on an impermeable geomembrane a minimum of 3 layers, each 0.762 mm (30 mils) thick, covered with a 0.254 mm (10 mils) sheet of geomembrane as specified. Place the geomembrane to prevent the stockpiled soil from coming into contact with surface water run-off. Locate the geomembrane cover to prevent rain or surface water from coming into contact with the contaminated soil, as well as limit the escape of the volatile constituents in the stockpile.

3.7.8 Acceptable Levels of Contamination

Take further samples and test soils with PID/FID readings of 50 ppm or greater for TPH and for BTEX in accordance with EPA SW-846 and EPA 600/4-79/020. For stockpiled soils, provide a minimum of one test for every 77 cubic meters (100 cubic yards) for TPH, and one test for every 77 cubic meters (100 cubic yards) for BTEX and TCLP. Soils that contain 50 ppm or more TPH, 50 ppm or more BTEX are considered contaminated materials. Soils which are less than the above may be used as clean fill. Furnish results to the Contracting Officer within 24 hours after the results are obtained.

3.8 REMOVAL OF PIPING, ANCILLARY EQUIPMENT, AND TANK

3.8.1 Piping and Ancillary Equipment

Disconnect all piping and ancillary equipment from the tank. Remove the piping completely (interior and exterior of the tank) as directed by the Contracting Officer. Cap all tank ancillary equipment and piping connections, except those connections necessary to inert the tank within the excavation zone. Clean the piping exterior and ancillary equipment to remove all soil and inspect for signs of corrosion and leakage. Ensure no spillage of the piping contents occurs, as specified in the Work Plan, and as required in paragraph SPILLS. If the soil under and around the tank pad is contaminated, remove the tank pad and dispose of offsite at an approved hazardous waste facility.

3.8.2 Tank

Remove the tank from the excavation and clean the exterior to remove all soil and inspect for signs of corrosion, structural damage, or leakage. Use only non-sparking type materials or equipment which comes into contact with the tank, or in the vicinity of the excavation such as shovels, slings and tools. After removal from the excavation, place the tank on a level surface adjacent to the tank excavation and secure it with wood blocks to prevent movement.

3.8.3 Contaminated Soil, Tank and Piping Excavation Examination

a. After the tank has been removed from the ground, examine and test the adjacent and underlying soil for any evidence of leakage. Visually inspect the soil for staining after removal of all obviously contaminated soil.

b. If tank is 6 m (20 feet) or less in length, take two samples. Take each sample 0.60 m (2 feet) from each end of the tank and 0.60 m (2 feet) below the bottom of the excavation.

c. If the tank is greater than 6 m (20 feet), take three samples. Take two samples 0.60 m (2 feet) from each end of the tank and 0.60 m (2 feet) below the bottom of the excavation. Take a third sample from the middle of the tank area and 0.60 m (2 feet) below the bottom of the excavation.

d. Analyze samples for TPH, BTEX, and TCLP. Perform sampling and analysis conforming to standards specified above for stockpiled soils. Soils that contain 50 ppm or more TPH, 10 ppm or more BTEX, or have TCLP reading of 10 ppm of lead or virgin petroleum products are considered contaminated materials. Soils which are less than the above may be used as clean fill. Furnish results to the Contracting Officer within 24 hours after the results are obtained. Along with the results furnish a sketch showing underground tank, sampling location, and extent of excavations.

e. Stockpile onsite in accordance with paragraph Stockpiles uncontaminated soil or petroleum contaminated soil not regulated by the state as hazardous waste. Stockpile contaminated soil or suspected contaminated soil, or, if the site is a RCRA-designated CAMU, containerized until further disposition.

f. The Contracting Officer will determine the extent of the contaminated soil to be removed from each site. Report any evidence indicating that the amount of contaminated soil may exceed the individual site limit specified, to the Contracting Officer the same day it is discovered. If minimal additional excavation is required, the Contracting Officer may allow the Contractor to proceed. If extensive contamination is encountered, sample the excavation and backfill in accordance with paragraph BACKFILLING.

3.8.4 Testing Along Piping

For every 7.5 m (25 linear feet) of product delivery piping, for every change in direction, and at every mechanical joint take one soil sample and analyze for TPH, BTEX, and TCLP. Ensure sampling and analysis of soil materials conforms to EPA standards specified above.

3.9 TANK CLEANING

3.9.1 Exterior

Remove soil from the exterior of the tank, piping, and associated equipment to eliminate soil deposition on roadways during transportation to a temporary storage area, ensure markings will adhere to the surfaces, and simplify tank cutting. Use non-sparking tools to remove soil. Recover removed uncontaminated soil and soil not regulated by the state as a hazardous waste and use them as backfill in the former tank excavation . Remove and containerize soil believed to be contaminated, or if the site is a RCRA designated CAMU, collect it on 3 layers of 0.762 mm (30 mil) impermeable geomembrane and stockpile it with other contaminated soil removed from the excavation.

3.9.2 Temporary Storage

If the tank is stored after the tank exterior is cleaned and ancillary equipment is removed, and prior to being cut into sections, label the tank as directed in API RP 1604, place it on blocks, and temporarily store it on a flat area adjacent to the excavation . Prior to cleaning the tank interior, monitor the tank atmosphere for combustible vapors and purge or inert it if combustible vapors are detected. Provide warning labels as follows:

"TANK HAS CONTAINED LEADED GASOLINE

NOT VAPOR FREE

NOT SUITABLE FOR STORAGE OF FOOD OR LIQUIDS
INTENDED FOR HUMAN OR ANIMAL CONSUMPTION

DATE OF REMOVAL: MONTH/DAY/YEAR"

3.9.3 Interior

Clean tank interior using a high pressure (greater than 3.45 MPa (500 psi)), low volume (less than 0.13 L/s (2 gpm)) water spray or Steam clean tank interior until all loose scale and sludge is removed, and contamination, in the form of a sheen, is no longer visible in the effluent stream. Also clean the interior surfaces of piping, to the extent possible, using the same method used for cleaning the tank. Contaminated water generated from interior cleaning operations (of both piping and tank) shall not exceed the following quantities for each UST cleaned:

UST VOLUME (LITERS) (GALLONS)	PERCENT OF UST VOLUME
3,785 or less (1,000 or less)	5
37,850 or less (10,000 or less)	5% or 378 L (100 gallons), whichever is less
75,700 or less (20,000 or less)	1% or 568 L (150 gallons)
greater than 75,700 (greater than 20,000)	1% or 946 L (250 gallons), whichever is less

Handle in accordance with paragraph Contaminated Water Disposal all contaminated water resulting from cleaning operations. Clean so as to eliminate, to the greatest extent possible, the need for personnel to enter the tank. Use specially designed tank cleaning equipment which allows the tank to be cleaned prior to cutting into sections without requiring personnel to enter the tank or, if less specialized equipment is used, the tank shall be partially dissected to overcome confined space entry hazards. Accomplish this work in accordance with Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES.

3.10 SOIL EXAMINATION, TESTING, AND ANALYSIS

3.10.1 Tank Excavation Sampling Procedures

After soil known to be contaminated has been removed or after soil excavation is complete, sample the excavation with procedures, number, location, and methodology in accordance with state regulations. Obtain samples from the pits using a backhoe with a Shelby tube attached to the bucket.

3.10.2 Stockpiled Material Sampling

Stockpiled contaminated soil shall be sampled and preserved in accordance with the approved Sampling and Analysis Plan.

3.10.3 Analysis

Test soil samples from the excavation and stockpiled material in accordance with the approved Sampling and Analysis Plan. Submit copies of all test results, including the chain-of-custody records, to the Contracting Officer.

3.11 BACKFILLING

a. Backfill the tank area and any other excavations only after the soil test results have been approved. Complete contaminated soil removal after the bottom of the tank excavation is determined to have soil contamination levels below the state standards of 100 ppm TPH.

b. Dewater the excavation if necessary. Use stockpiled material, subjected to chemical confirmation testing as backfill, if it is found to contain less than 100 ppm of total petroleum hydrocarbons (TPH). Place clean backfill in layers with a maximum loose thickness of 200 mm 8 inches, compacted to 90 percent maximum density for cohesive soils and 95 percent maximum density for cohesionless soils. Perform density tests using an approved commercial testing laboratory or by facilities furnished by the Contractor. Attach test results to Contractor's Quality Control Report and Tank Closure Report; Perform a minimum of 1 density test on each lift. Determine laboratory tests for moisture density relations in accordance with ASTM D1557, Method B, C, or D, or ASTM D6938. A mechanical tamper may be used, provided that the results are correlated with those obtained by the hand tamper. Determine field in-place density shall be in accordance with ASTM D1556, ASTM D6938, ASTM D2167, or KS F 2347.

3.12 DISPOSAL REQUIREMENTS

3.12.1 Treatment, Disposal, and Recycling

Perform disposal of wastes in accordance with ROK national, provincial and local laws; Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS; and conditions specified herein. This work includes all necessary personnel, labor, transportation, packaging, detailed analyses (if required for disposal, manifesting or completing waste profile sheets), equipment, and reports. Recycle product and pumpable liquids removed from the tank to the greatest extent practicable.

3.12.2 Tank and Ancillary Equipment Disposal

After the tank, piping, and ancillary equipment have been removed from the excavation and the tank cleaned, cut the tank into sections with no dimension greater than 1500 mm (5 feet). Dispose of tank and piping sections in a ROK approved offsite disposal facility or in a salvage yard. Perform tank cutting prior to being taken from the tank removal site. Do not sell the tank intact. Dispose of ancillary equipment at an approved offsite disposal facility or a salvage yard Piping shall be disconnected from the tank and removed unless otherwise indicated.

3.12.3 Transportation of Wastes

Transportation shall be provided in accordance with Korean Ministry of Environment Designated Waste Collection and Transportation Regulations including obtaining all necessary permits, licenses, and approvals.

3.12.4 Salvage Rights

The Contractor retains the rights to salvage value of recycled or reclaimed product and metal not turned in to the DRMO or otherwise identified, so long as the requirements of ROK national, provincial and local laws. At the end of the contract, provide documentation on the disposition of salvaged materials.

3.12.5 Manifest Records

Maintain records of all waste determinations, including appropriate results of analyses performed, substances and sample location, the time of collection, and other pertinent data as required by 40 CFR 280, Section 74 and 40 CFR 262 Subpart D. Also record transportation, treatment, disposal methods and dates, the quantities of waste, the names and addresses of each transporter and the disposal or reclamation facility, shall and available for inspection, as well as copies of the following documents:

a. Manifests.

b. Waste analyses or waste profile sheets.

c. Certifications of final treatment/disposal signed by the responsible disposal facility official.

d. Land disposal notification records required under 40 CFR 268 for hazardous wastes.

Provide records in accordance with Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS. Upon contract close out, the records will become the property of the Government.

3.12.6 Hazardous/Special Waste Manifests

Provide manifesting conforming to the requirements of the ROK Government.

3.12.7 Documentation of Treatment or Disposal

Take wastes, other than recyclable or reclaimable product or metal, to a treatment, storage, or disposal facility which has EPA or appropriate ROK national, provincial, and local permits and hazardous or special waste identification numbers and complies with the provisions of the disposal regulations. Furnish the original return copy of the hazardous waste manifest, signed by the owner or operator of a facility legally permitted to treat or dispose of those materials shall be furnished to the Contracting Officer not later than 5 working days following the delivery of those materials to the facility; and include a copy in the Tank Closure Report. Furnish a statement of agreement from the proposed treatment, storage or disposal facility and certified transporters to accept hazardous or special wastes to the Contracting Officer not less than 14 days before transporting any wastes.

3.13 SPILLS

Use appropriate vehicles and operating practices to prevent spillage or leakage of contaminated materials from occurring during operations. Inspect vehicles leaving the area of contamination to ensure that no contaminated materials adhere to the wheels or undercarriage. Take immediate containment actions as necessary to minimize effect of any spill or leak. Cleanup in accordance with applicable ROK national, provincial, and local laws and regulations, and district policy at no additional cost to the Government. Refer to Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS for spill response and reporting requirements.

3.14 INSPECTIONS

Arrange for and perform required inspections. Provide copies of inspections to Contracting Officer.

3.15 TANK CLOSURE REPORT

Submit one hard copy & one digital copy (.pdf - text searchable) of a Closure Report for each UST removed within 45 days of removal of the UST or removal of the last UST if part of a larger UST removal project where multiple USTs are involved. Report shall be indexed, bookmarked, and include a cover page with contract number, project name, location(s), and tank number(s). Hard copy shall be prepared in a standard 3-ring binder.

Include in Tank Closure Reports the following information as a minimum:

a. A cover letter signed by a registered Professional Engineer who is a responsible company official, certifying that all services involved have been performed in accordance with the terms and conditions of this specification.

b. A narrative report describing what was encountered at each site, including:

   (1) condition of the UST.

   (2) any visible evidence of leaks or stained soils.

   (3) results of vapor monitoring readings of the excavation area using photo-ionization/flame-ionization detectors (PID/FID).

   (4) actions taken including quantities of materials (including, but not limited to, fuel, fuel-water mixtures, soil) removed.

   (5) reasons for selecting sample locations.

   (6) sample locations.

   (7) collection data such as time of collection and method of preservation.

   (8) reasons for backfilling site.

   (9) whether or not groundwater was encountered.

   (10) whether or not groundwater was encountered.

c. Copies of all analyses performed for disposal.

d. Copies of all waste analyses or waste profile sheets.

e. Copies of all certifications of final disposal signed by the responsible disposal installation official.

f. Information on who sampled, analyzed, transported, and accepted all wastes encountered, including copies of manifests, waste profile sheets, land disposal restriction, notification and certification forms, certificates of disposal, and other pertinent documentation.

g. Copies of all analyses performed, with copies of chain-of-custody for each sample. Analyses shall give the identification number of the sample used. Sample identification numbers shall correspond to those provided on the one-line drawings.

h. Scaled one-line drawings showing tank locations, limits of excavation, limits of contamination, underground utilities within 15 m 50 feet, sample locations, and sample identification numbers.

i. Progress Photographs. Take a minimum of 4 photographic views of the site showing such things as the location of each tank, entrance/exit road, and any other notable site condition before work begins. After work has been started at the site, photographically record activities at each work location daily. Photographs shall be digital, 1600x1200x24 bit true color, 8 megapixel minimum resolution in JPEG file format:

(1) Soil removal, handling, and sampling.

(2) Unanticipated events such as discovery of additional contaminated areas.

(3) Soil stockpile area.

(4) Tank.

(5) Site or task-specific employee respiratory and personal protection.

(6) Fill placement and grading.

(7) Fill placement and grading.

(8) Post-construction photographs. After completion of work at each site, take a minimum of four (4) photographic views of the site. Provide digital photographs for the hard copy of the closure report on a separate CD-R, cumulative of all photos to date. Each photograph shall have an information box associated with it. The box shall be typewritten and arranged as follows:

Project No.	Contract No.
Location	
Contractor/Photographer	
Photograph No.	Date/Time:
Description	
Direction of View	

3.16 COMPACTION, FINISH GRADING, and SEEDING

Provide backfill, compaction, grading, and seeding in accordance with Section 31 00 00 EXCAVATION.

-- End of Section --

SECTION 02 81 00

TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

IATA DGR	(2004) Dangerous Goods Regulations

U.S. ARMY CORPS OF ENGINEERS (USACE)

EP 415-1-266	(2000) Resident Engineer Management Guide (REMG) for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities
40 CFR 268	Land Disposal Restrictions
40 CFR 270	EPA Administered Permit Programs: The Hazardous Waste Permit Program
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
40 CFR 302	Designation, Reportable Quantities, and Notification

40 CFR 61	National Emission Standards for Hazardous Air Pollutants
40 CFR 761	Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
49 CFR 173	Shippers - General Requirements for Shipments and Packagings
49 CFR 178	Specifications for Packagings

1.2 DEFINITIONS

1.2.1 Hazardous Material

A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated pursuant to the Hazardous Materials Transportation Act, 49 U.S.C. Appendix Section 1801 et seq. The term includes materials designated as hazardous materials under the provisions of 49 CFR 172, Sections .101 and .102 and materials which meet the defining criteria for hazard classes and divisions in 49 CFR 173. EPA designated hazardous wastes are also hazardous materials.

1.2.2 Hazardous Waste

A waste which meets criteria established in RCRA or specified by the EPA in 40 CFR 261 or which has been designated as hazardous by a RCRA authorized state program.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Onsite Hazardous Waste Management; G
Notices of Non-Compliance and Notices of Violation
Packaging Notifications

SD-06 Test Reports

Record keeping; G
Spill Response
Exception Report; G

SD-07 Certificates

Certification
Security Plan
Transportation and Disposal Coordinator; G
Training; G
EPA Offsite Policy
Certificates of Disposal
Shipping Documents and Packagings Certification; G
Waste Minimization; G

1.4 QUALITY ASSURANCE

1.4.1 Transportation and Disposal Coordinator

Designate, by position and title, one person to act as the Transportation and Disposal Coordinator (TDC) for this contract. The TDC shall serve as the single point of contact for all environmental regulatory matters and shall have overall responsibility for total environmental compliance at the site including, but not limited to, accurate identification and classification of hazardous waste and hazardous materials; determination of proper shipping names; identification of marking, labeling, packaging and placarding requirements; completion of waste profiles, hazardous waste manifests, asbestos waste shipment records, PCB manifests, bill of ladings, exception and discrepancy reports; and all other environmental documentation. The TDC shall have, at a minimum, one year of specialized experience in the management and transportation of hazardous waste and have been Department of Transportation certified under 49 CFR 172, Subpart H.

1.4.2 Training

The Contractor's hazardous materials employees shall be trained, tested, and certified to safely and effectively carry out their assigned duties in accordance with Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES . The Contractor's employees transporting hazardous materials or preparing hazardous materials for transportation, including samples, shall be trained, tested, and certified in accordance with 49 CFR 172, Subpart H, including security awareness and any applicable security plans. Where shipment of hazardous materials by air may be occurring, such as for sample shipments, the Contractor's hazardous material employees shall also be trained on IATA DGR. Contractor employees making determinations that shipments do not constitute DOT regulated hazardous materials shall also be trained, tested, and certified in accordance with 49 CFR 172, Subpart H.

1.4.3 Certification

The Contractor and/or subcontractors transporting hazardous materials shall possess a current certificate of registration issued by the Korean Ministry of Environment. Submit copies of the certificates or written statements certifying exemption from these requirements.

1.4.4 Laws and Regulations Requirements

Work shall meet or exceed the minimum requirements established by ROK national, provincial, and local laws and regulations which are applicable. These requirements are amended frequently and compliance with amendments is required as they become effective. In the event that compliance exceeds the scope of work or conflicts with specific requirements of the contract, notify the Contracting Officer immediately.

PART 2 PRODUCTS

2.1 MATERIALS

Provide all the materials required for the packaging, labeling, marking, placarding and transportation of hazardous wastes and hazardous materials in conformance with Department of Transportation standards and EP 415-1-266. Details in this specification shall not be construed as establishing the limits of the Contractor's responsibility.

2.1.1 Packagings

Provide bulk containers for packaging hazardous materials/wastes consistent with the authorizations referenced in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 8 and in accordance with the regulations of the Korean Ministry of Environment. Bulk and non-bulk packaging shall meet the corresponding specifications in 49 CFR 173 referenced in the Hazardous Materials Table, 49 CFR 172, Section .101. Each packaging shall conform to the general packaging requirements of Subpart B of 49 CFR 173, to the requirements of 49 CFR 178 at the specified packing group performance level, to the requirements of special provisions of column 7 of the Hazardous Materials Table in 49 CFR 172, Section .101, and shall be compatible with the material to be packaged as required by 40 CFR 262. Also provide other packaging related materials such as materials used to cushion or fill voids in overpacked containers, etc. Sorbent materials shall not be capable of reacting dangerously with, being decomposed by, or being ignited by the hazardous materials being packaged. Additionally, sorbents used to treat free liquids to be disposed of in landfills shall be non-biodegradable as specified in 40 CFR 264, Section .314. In addition, packaging notifications will be provided to the Government in accordance with 49 CFR 172, Section .178.2(c) regarding type and dimensions of closures, including gaskets, needed to satisfy performance test requirements.

2.1.2 Markings

Provide markings for each hazardous material/waste package, freight container, and transport vehicle consistent with the requirements of 49 CFR 172, Subpart D and 40 CFR 262, Section .32 (for hazardous waste) and as required by the Korean Ministry of Environment. Markings shall be capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

2.1.3 Labeling

Provide primary and subsidiary labels for hazardous materials/wastes consistent with the requirements in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 6. Labels shall meet design specifications required by 49 CFR 172, Subpart E including size, shape, color, printing, and symbol requirements. Labels shall be durable and weather resistant and capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

2.1.4 Placards

For each offsite shipment of hazardous material/waste, provide primary and subsidiary placards consistent with the requirements of 49 CFR 172, Subpart F. Placards shall be provided for each side and each end of bulk packaging, freight containers, transport vehicles, and rail cars requiring such placarding. Placards may be plastic, metal, or other material capable of withstanding, without deterioration, a 30 day exposure to open weather conditions and shall meet design requirements specified in 49 CFR 172, Subpart F.

2.1.5 Spill Response Materials

Provide spill response materials including, but not limited to, containers, adsorbent, shovels, and personal protective equipment. Spill response materials shall be available at all times in which hazardous materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of material being handled.

2.2 EQUIPMENT AND TOOLS

Provide miscellaneous equipment and tools necessary to handle hazardous materials and hazardous wastes in a safe and environmentally sound manner.

PART 3 EXECUTION

3.1 ONSITE HAZARDOUS WASTE MANAGEMENT

These paragraphs apply to Government owned waste only. Contractors are prohibited by 10 U.S.C. 2692 from storing Contractor owned waste onsite for any length of time. The Contractor is responsible for ensuring compliance with ROK national, provincial, and local hazardous waste laws and regulations and shall verify those requirements when preparing reports, waste shipment records, hazardous waste manifests, or other documents. Identify hazardous wastes using criteria set forth in 40 CFR 261 or all applicable ROK national, provincial, and local laws, regulations, and ordinances. When accumulating hazardous waste onsite, comply with generator requirements in 40 CFR 262 and any applicable ROK law or regulations. Onsite accumulation times shall be restricted to applicable time frames referenced in 40 CFR 262, Section .34 and any applicable ROK national, provincial, or local law or regulation. Accumulation start dates shall commence when waste is first generated (i.e. containerized or otherwise collected for discard). Only use containers in good condition and compatible with the waste to be stored. Ensure containers are closed except when adding or removing waste, and immediately mark all hazardous waste containers with the words "hazardous waste" and other information required by 40 CFR 262, Section .32 and any applicable ROK national, provincial, or local law or regulation as soon as the waste is containerized. An additional marking shall be placed on containers of "unknowns" designating the date sampled, and the suspected hazard. Inspect containers for signs of deterioration and for responding to any spills or leaks. Inspect all hazardous waste areas weekly and provide written documentation of the inspection. Include date and time of inspection, name of individual conducting the inspection, problems noted, and corrective actions taken on the inspection logs.

3.1.1 Hazardous Waste Classification

Identify, in consultation with the Contracting Officer , all waste codes applicable to each hazardous waste stream based on requirements in 40 CFR 261 or any applicable ROK national, provincial, or local law or regulation. Also identify all applicable treatment standards in 40 CFR 268 and state land disposal restrictions and make a determination as to whether or not the waste meets or exceeds the standards. Waste profiles, analyses, classification and treatment standards information shall be submitted to Contracting Officer for review and approval.

3.1.2 Management Plan

Prepare a plan detailing the manner in which hazardous wastes will be managed and describing the types and volumes of hazardous wastes anticipated to be managed as well as the management practices to be utilized. The plan shall identify the method to be used to ensure accurate piece counts and/or weights of shipments; shall identify waste minimization methods; shall propose facilities to be utilized for treatment, storage, and/or disposal; shall identify areas onsite where hazardous wastes are to be handled; and shall identify whether transfer facilities are to be utilized; and if so, how the wastes will be tracked to ultimate disposal. Submit the plan prior to start of work. Written documentation of weekly hazardous waste inspections shall be submitted on a monthly basis.

3.2 OFFSITE HAZARDOUS WASTE MANAGEMENT

Use RCRA Subtitle C permitted facilities which meet the requirements of 40 CFR 264 or facilities operating under interim status which meet the requirements of 40 CFR 265 and facilities approved by the Korean Ministry of Environment. Offsite treatment, storage, and/or disposal facilities with significant RCRA violations or compliance problems (such as facilities known to be releasing hazardous constituents into ground water, surface water, soil, or air) shall not be used. Submit Notices of Non-Compliance and Notices of Violation by the Korean Ministry of Environment issued to the Contractor in relation to any work performed under this contract. Immediately provide copies of such notices to the Contracting Officer. Also furnish all relevant documents regarding the incident and any information requested by the Contracting Officer, and coordinate its response to the notice with the Contracting Officer or the designated representative prior to submission to the notifying authority. Also furnish a copy to the Contracting Officer of all documents submitted to the regulatory authority, including the final reply to the notice, and all other materials, until the matter is resolved.

3.2.1 Treatment, Storage, and/or Disposal Facility and Transporter

Provide the Contracting Officer with names, locations, and telephone numbers of TSD facilities and transporters. This information shall be contained in the Hazardous Waste Management Plan and shall be approved by the Contracting Officer prior to waste disposal.

3.2.2 Status of the Facility

Facilities receiving hazardous waste shall be permitted in accordance with 40 CFR 270 or operating under interim status in accordance with 40 CFR 265 requirements, or permitted by the Korean Ministry of Environment. Additionally, prior to using a TSD Facility, contact the EPA Regional Offsite Coordinator specified in 40 CFR 300, Section .440, to determine the facility's status, and document all information necessary to satisfy the requirements of the EPA Offsite policy and submit this information to the Contracting Officer.

3.2.3 Shipping Documents and Packagings Certification

Prior to shipment of any hazardous material offsite and a minimum of 14 days prior to anticipated pickup, the Contractor's TDC shall provide for review written certification to the Contracting Officer that hazardous materials have been properly packaged, labeled, and marked in accordance with Department of Transportation, EPA, and Korean Ministry of Environment requirements. Packaging assurances shall be furnished by the designated disposal facility not later than 35 days after acceptance of the shipment. The Contractor's TDC shall also provide written certification regarding waste minimization efforts documenting that efforts have been taken to reduce the volume and toxicity of waste to the degree economically practicable and that the method of treatment, storage, or disposal selected minimizes threats to human health and the environment.

3.2.4 Transportation

Prior to conducting hazardous materials activities, the Contractor responsible for pre-transportation activities shall either certify to the Government that a Security Plan is in place which meets the requirements of 49 CFR 172, Subpart I or in the event that the types or amounts of hazardous materials are excluded from the security planning requirements, a written statement to that effect detailing the basis for the exception. Use manifests for transporting hazardous wastes as required by 40 CFR 263 or any applicable ROK national, provincial, or local law or regulation. Transportation shall comply with all requirements in the Department of Transportation referenced regulations in the 49 CFR series. Prepare hazardous waste manifests for each shipment of hazardous waste shipped offsite. Manifests shall be completed using instructions in 40 CFR 262, Subpart B and any applicable ROK national, provincial, or local law or regulation. Submit manifests and waste profiles to Contracting Officer for review and approval. Prepare land disposal restriction notifications as required by 40 CFR 268 or any applicable ROK national, provincial, or local law or regulation for each shipment of hazardous waste. Submit notifications with the manifest to the Contracting Officer for review and approval. Inspect motor vehicles used to transport hazardous materials in accordance with applicable ROK national, provincial, or local laws or regulations.

3.2.5 Treatment and Disposal of Hazardous Wastes

The hazardous waste shall be transported to an approved hazardous waste treatment, storage, or disposal facility within 90 days of the accumulation start date on each container . Ship hazardous wastes only to facilities which are properly permitted to accept the hazardous waste or operating under interim status. Ensure wastes are treated to meet land disposal treatment standards in 40 CFR 268 prior to land disposal. Propose TSD facilities via submission of the Hazardous Waste Management Plan, subject to the approval of the Contracting Officer. Submit Certificates of Disposal documenting the ultimate disposal, destruction or placement of hazardous wastes, CERCLA remediation waste, polychlorinated biphenyls (PCBs), and/or asbestos within 180 days of initial shipment. Receipt of these certificates will be required for final payment.

3.3 RADIOACTIVE MATERIALS MANAGEMENT

In consultation with the Contracting Officer , evaluate, prior to shipment of any material offsite, whether the material is regulated as a hazardous waste in addition to being regulated as a radioactive material; this shall be done for the purpose of determining proper shipping descriptions, marking requirements, etc., as described below.

3.3.1 Identification of Proper Shipping Names

Use 49 CFR 172, Section .101 to identify proper shipping names for each hazardous material (including hazardous wastes) to be shipped offsite. Submit proper shipping names to the Contracting Officer in the form of draft shipping documents for review and approval.

3.3.2 Packaging, Labeling, and Marking

Package, label, and mark hazardous materials/wastes using the specified materials and in accordance with the referenced authorizations. Mark each container of hazardous waste of 416 L (110 gallons) or less with the following:

"HAZARDOUS WASTE - Federal Law Prohibits Improper Disposal.
If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.
Generator's name ____________________________________
Manifest Document Number ___________________________".

3.3.3 Shipping Documents

Ensure that each shipment of hazardous material sent offsite is accompanied by properly completed shipping documents.

3.3.3.1 PCB Waste Shipment Documents

Prepare hazardous waste manifests for each shipment of PCB waste shipped offsite. Complete manifests using instructions in 40 CFR 761, Sections .207 and .208 and all other applicable requirements. Submit documents to Contracting Officer for review and approval.

3.3.3.2 Asbestos Waste Shipment Documents

Prepare waste shipment records, as required by 40 CFR 61 and applicable ROK national, provincial, or local standards for shipments of asbestos. Submit waste shipment records to the Contracting Officer for review and approval. Waste shipment records shall be signed by the Contractor.

3.3.3.3 Other Hazardous Material Shipment Documents

Prepare a bill of lading for each shipment of hazardous material which is not accompanied by a hazardous waste manifest or asbestos waste shipment record which fulfills the shipping paper requirements. The bill of lading shall satisfy the requirements of 49 CFR 172, Subpart C, and any applicable ROK national, provincial, or local law or regulation, and shall be submitted to the Contracting Officer for review and approval. For laboratory samples and treatability study samples, prepare bills of lading and other documentation as necessary to satisfy conditions of the sample exclusions in 40 CFR 261, Section .4(d) and (e) and any applicable ROK national, provincial, or local law or regulation. Bill of ladings requiring shipper's certifications shall be signed by the Contractor.

3.4 SPECIAL REQUIREMENTS FOR ASBESTOS WASTES

If work involves asbestos containing wastes, manage these wastes in accordance with specification Section 02 82 14.00 10 ASBESTOS HAZARD CONTROL ACTIVITIES.

3.5 WASTE MINIMIZATION

Minimize the generation of hazardous waste to the maximum extent practicable and take all necessary precautions to avoid mixing clean and contaminated wastes. Identify and evaluate recycling and reclamation options as alternatives to land disposal. Requirements of 40 CFR 266 shall apply to: hazardous wastes recycled in a manner constituting disposal; hazardous waste burned for energy recovery; lead-acid battery recycling; and hazardous wastes with economically recoverable precious metals. Submit written certification that waste minimization efforts have been undertaken to reduce the volume and toxicity of waste to the degree economically practicable and that the method of treatment, storage, or disposal selected minimizes threats to human health and the environment.

3.6 RECORD KEEPING

The Contractor is responsible for maintaining adequate records to support information provided to the Contracting Officer regarding exception reports, annual reports, and biennial reports; maintaining asbestos waste shipment records for a minimum of 3 years from the date of shipment or any longer period required by any applicable law or regulation or any other provision of this contract; and maintaining bill of ladings for a minimum of 375 days from the date of shipment or any longer period required by any applicable law or regulation or any other provision of this contract. Submit information necessary to file state annual or EPA biennial reports for all hazardous waste transported, treated, stored, or disposed of under this contract. Do not forward these data directly to the regulatory agency but to the Contracting Officer at the specified time. The submittal shall contain all the information necessary for filing of the formal reports in the form and format required by the governing Federal or state regulatory agency. A cover letter shall accompany the data to include the contract number, Contractor name, and project location. In the events that a manifest copy documenting receipt of hazardous waste at the treatment storage and disposal facility is not received within 35 days of shipment initiation, or that a manifest copy documenting receipt of PCB waste at the designated facility is not received within 35 days of shipment initiation, prepare and submit an exception report to the Contracting Officer within 37 days of shipment initiation.

3.7 SPILL RESPONSE

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), or pollutant or contaminant, or oil (as governed by the Oil Pollution Act (OPA), 33 U.S.C. 2701 et seq.), notify the Contracting Officer immediately. Any direction from the Contracting Officer concerning a spill or release shall not be considered a change under the contract. If the spill exceeds a reporting threshold, follow the pre-established procedures for immediate reporting to the Contracting Officer. Comply with all applicable requirements of ROK national, provincial, or local laws or regulations regarding any spill incident.

3.8 EMERGENCY CONTACTS

The Contractor is responsible for complying with the emergency contact provisions in 49 CFR 172, Section .604. Whenever the Contractor ships hazardous materials, provide a 24 hr emergency response contact and phone number of a person knowledgeable about the hazardous materials being shipped and who has comprehensive emergency response and incident mitigation information for that material, or has immediate access to a person who possesses such knowledge and information. The phone shall be monitored on a 24 hour basis at all times when the hazardous materials are in transportation, including during storage incidental to transportation. Ensure that information regarding this emergency contact and phone number are placed on all hazardous material shipping documents. Designate an emergency coordinator and post the following information at areas in which hazardous wastes are managed:

a. The name of the emergency coordinator.

b. Phone number through which the emergency coordinator can be contacted on a 24 hour basis.

c. The telephone number of the local fire department.

d. The location of fire extinguishers and spill control materials.

-- End of Section --

SECTION 02 82 14.00 10

ASBESTOS HAZARD CONTROL ACTIVITIES
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA)

AIHA Z9.2	(2006) Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE Z87.1	(2003) Standard for Occupational and Educational Eye and Face Protection

ASTM INTERNATIONAL (ASTM)

ASTM D 1331	(1989; R 2001) Surface and Interfacial Tension of Solutions of Surface-Active Agents
ASTM D 4397	(2009) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM E 1368	(2005e1) Visual Inspection of Asbestos Abatement Projects

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-7	(2008) Compressed Air for Human Respiration; 6th Edition

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 701	(2010) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 94-113	(1994; 4th Ed) NIOSH Manual of Analytical Methods

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

EP 1110-1-11	(1992; Change 1 1997) Engineering and Design -- Asbestos Abatement Guideline Detail Sheets

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 340/1-90/018	(1990) Asbestos/NESHAP Regulated Asbestos Containing Materials Guidance

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.134	Respiratory Protection
29 CFR 1910.141	Sanitation
29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1926.1101	Asbestos
29 CFR 1926.32	Safety and Health Regulations for Construction - Definition
40 CFR 61	National Emission Standards for Hazardous Air Pollutants
40 CFR 763	Asbestos
42 CFR 84	Approval of Respiratory Protective Devices

UNDERWRITERS LABORATORIES (UL)

UL 586	(2009; Reprint Sep 2014) Standard for High-Efficiency Particulate, Air Filter Units

REPUBLIC OF KOREA (ROK) LAW

Act No. 10389	(23 JUL 2010) Korean Waste Management Act (WMA)
PD No. 22631	(21 JAN 2011) Korean Presidential Decree (PD) of WMA
MD No. 406	(31 MAR 2011) Korean Ministry of Environment, Ministerial Decree (MD) of WMA

U.S. FORCES KOREA (USFK)

USFK Reg 201-1	(20120618) ENVIRONMENTAL GOVERNING STANDARDS (EGS)

KOREAN INDUSTRIAL STANDARDS (KS)

KS T 1093	(2008) Polyethylene Films for Packaging

1.2 DEFINITIONS

1.2.1 Amended Water

Water containing a wetting agent or surfactant with a surface tension of at least 29 dynes per square centimeter when tested in accordance with ASTM D 1331.

1.2.2 Asbestos-Containing Material (ACM)

Any materials containing more than one percent asbestos.

1.2.3 Authorized Person

Any person authorized by the Contractor and required by work duties to be present in the regulated areas.

1.2.4 Building Inspector

Individual who inspects buildings for asbestos and has EPA Model Accreditation Plan (MAP) "Building Inspector" training; accreditation required by 40 CFR 763, Subpart E, Appendix C, has EPA certification/license as a "Building Inspector".

1.2.5 Class I Asbestos Work

Activities defined by OSHA involving the removal of thermal system insulation (TSI) and surfacing ACM.

1.2.6 Class II Asbestos Work

Activities defined by OSHA involving the removal of ACM which is not thermal system insulation or surfacing material. This includes, but is not limited to, the removal of asbestos - containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastic. Certain "incidental" roofing materials such as mastic, flashing and cements when they are still intact are excluded from Class II asbestos work. Removal of small amounts of these materials which would fit into a glove bag may be classified as a Class III job.

1.2.7 Class III Asbestos Work

Activities defined by OSHA that involve repair and maintenance operations, where ACM, including TSI and surfacing ACM, is likely to be disturbed. Operations may include drilling, abrading, cutting a hole, cable pulling, crawling through tunnels or attics and spaces above the ceiling, where asbestos is actively disturbed or asbestos-containing debris is actively disturbed.

1.2.8 Class IV Asbestos Work

Maintenance and custodial construction activities during which employees contact but do not disturb ACM and activities to clean-up dust, waste and debris resulting from Class I, II, and III activities. This may include dusting surfaces where ACM waste and debris and accompanying dust exists and cleaning up loose ACM debris from TSI or surfacing ACM following construction

1.2.9 Clean Room

An uncontaminated room having facilities for the storage of employees' street clothing and uncontaminated materials and equipment.

1.2.10 Competent Person

In addition to the definition in 29 CFR 1926.32(f), a person who is capable of identifying existing asbestos hazards as defined in 29 CFR 1926.1101, selecting the appropriate control strategy, has the authority to take prompt corrective measures to eliminate them and has EPA Model Accreditation Plan (MAP) "Contractor/Supervisor" training; has EPA certification/license as a "Contractor/Supervisor".

1.2.11 Contractor/Supervisor

Individual who supervises asbestos abatement work and has EPA Model Accreditation Plan "Contractor/Supervisor" training; has EPA certification as a "Contractor/Supervisor".

1.2.12 Critical Barrier

One or more layers of plastic sealed over all openings into a regulated area or any other similarly placed physical barrier sufficient to prevent airborne asbestos in a regulated area from migrating to an adjacent area.

1.2.13 Decontamination Area

An enclosed area adjacent and connected to the regulated area and consisting of an equipment room, shower area, and clean room, which is used for the decontamination of workers, materials, and equipment that are contaminated with asbestos.

1.2.14 Demolition

The wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos products.

1.2.15 Disposal Bag

A 0.15 mm (6 mil) thick, leak-tight plastic bag, pre-labeled in accordance with 29 CFR 1926.1101, used for transporting asbestos waste from containment to disposal site.

1.2.16 Disturbance

Activities that disrupt the matrix of ACM, crumble or pulverize ACM, or generate visible debris from ACM. Disturbance includes cutting away small amounts of ACM, no greater than the amount which can be contained in 1 standard sized glove bag or waste bag, not larger than 1.5 m (60 inches) in length and width in order to access a building component.

1.2.17 Equipment Room or Area

An area adjacent to the regulated area used for the decontamination of employees and their equipment.

1.2.18 Fiber

A fibrous particulate, 5 micrometers or longer, with a length to width ratio of at least 3 to 1.

1.2.19 Friable ACM

A term defined in 40 CFR 61, Subpart M and EPA 340/1-90/018 meaning any material which contains more than 1 percent asbestos, as determined using the method specified in 40 CFR 763, Polarized Light Microscopy (PLM), that when dry, can be crumbled, pulverized, or reduced to powder by hand pressure.

1.2.20 Glove bag

Not more than a 1.5 by 1.5 m (60 by 60 inch) impervious plastic bag-like enclosure affixed around an asbestos-containing material, with glove-like appendages through which material and tools may be handled.

1.2.21 High-Efficiency Particulate Air (HEPA) Filter

A filter capable of trapping and retaining at least 99.97 percent of all mono-dispersed particles of 0.3 micrometers in diameter.

1.2.22 Intact

ACM which has not crumbled, been pulverized, or otherwise deteriorated so that the asbestos is no longer likely to be bound with its matrix. Removal of "intact" asphaltic, resinous, cementitious products does not render the ACM non-intact simply by being separated into smaller pieces.

1.2.23 Model Accreditation Plan (MAP)

US EPA training accreditation requirements for persons who work with asbestos as specified in 40 CFR 763.

1.2.24 Negative Initial Exposure Assessment

A demonstration by the Contractor to show that employee exposure during an operation is expected to be consistently below the OSHA Permissible Exposure Limits (PELs).

1.2.25 NESHAP

National Emission Standards for Hazardous Air Pollutants. The US EPA NESHAP regulation for asbestos is at 40 CFR 61, Subpart M.

1.2.26 Nonfriable ACM

A NESHAP term defined in 40 CFR 61, Subpart M and EPA 340/1-90/018 meaning any material containing more than 1 percent asbestos that, when dry, cannot be crumbled, pulverized or reduced to powder by hand pressure.

1.2.27 Nonfriable ACM (Category I)

A NESHAP term defined in 40 CFR 61, Subpart E and EPA 340/1-90/018 meaning asbestos-containing packing, gaskets, resilient floor covering, and asphalt roofing products containing more than 1 percent asbestos.

1.2.28 Nonfriable ACM (Category II)

A NESHAP term defined in 40 CFR 61, Subpart E and EPA 340/1-90/018 meaning any material, excluding Category I nonfriable ACM, containing more than 1 percent asbestos.

1.2.29 Permissible Exposure Limits (PEL)

1.2.29.1 PEL-Time Weighted Average (TWA)

Concentration of asbestos not in excess of 0.1 fibers per cubic centimeter of air (f/cc) as an 8 hour time weighted average (TWA).

1.2.29.2 PEL-Excursion Limit

An airborne concentration of asbestos not in excess of 1.0 f/cc of air as averaged over a sampling period of 30 minutes.

1.2.30 Regulated Area

An OSHA term defined in 29 CFR 1926.1101 meaning an area established by the Contractor to demarcate areas where Class I, II, and III asbestos work is conducted; also any adjoining area where debris and waste from such asbestos work accumulate; and an area within which airborne concentrations of asbestos exceed, or there is a reasonable possibility they may exceed, the permissible exposure limit.

1.2.31 Removal

All operations where ACM is taken out or stripped from structures or substrates, including demolition operations.

1.2.32 Thermal System Insulation (TSI) ACM

ACM which contains more than 1% asbestos and is applied to pipes, fittings, boilers, breeching, tanks, ducts, or other interior structural components to prevent heat loss or gain or water condensation.

1.2.33 Transite

A generic name for asbestos cement wallboard and pipe.

1.2.34 Worker

Individual (not designated as the Competent Person or a supervisor) who performs asbestos work and has completed asbestos worker training required by 29 CFR 1926.1101, to include EPA Model Accreditation Plan (MAP) "Worker" training; accreditation if required by the OSHA Class of work to be performed.

1.3 SYSTEM DESCRIPTION

This section covers all operations in which asbestos-containing materials (ACM) are encountered. These procedures and equipment are required to protect workers and building occupants from airborne asbestos fibers and ACM dust and debris. Activities include OSHA Class I, Class II, Class III, or Class IV work operations. This section also includes containment, storage, transportation and disposal of the generated ACM wastes. Submit Detailed Drawings in accordance with EP 1110-1-11 and containing

descriptions, and site layout to include worksite containment area(s), local exhaust systems locations, decontamination units and load-out units, other temporary waste storage facility, location of temporary utilities (electrical, water, sewer) and boundaries of each regulated area. When the detail sheets are not attached to this specification, the Contractor can get them from the web at:
http://140.194.76.129/publications/eng-pamphlets/ep1110-1-11/toc.htm

1.3.1 Abatement Work Tasks

The specific ACM to be abated is identified on the detailed plans and project drawings.

1.3.2 Unexpected Discovery of Asbestos

For any previously untested building components suspected to contain asbestos and located in areas impacted by the work, notify the Contracting Officer (CO) who will have the option of ordering up to 10 bulk samples to be obtained at the Contractor's expense and delivered to a laboratory accredited under the National Institute of Standards and Technology (NIST) "National Voluntary Laboratory Accreditation Program (NVLAP)" and analyzed by PLM. If the asbestos content is less than 10 percent, as determined by a method other than point counting, the asbestos content shall be verified by point counting. Any additional components identified as ACM that have been approved by the CO for removal shall be removed and will be paid for by an equitable adjustment to the contract price under the CONTRACT CLAUSE titled "changes". Sampling shall be conducted by personnel who have successfully completed the EPA Model Accreditation Plan (MAP) "Building Inspector" training course and is EPA certified/licensed as a "Building Inspector".

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings; G

SD-03 Product Data

Asbestos Waste Shipment Records
Encapsulants
Respiratory Protection Program; G
Cleanup and Disposal
Qualifications; G
Training Program
Licenses, Permits and Notifications
Asbestos Management Plan

SD-06 Test Reports

Exposure Assessment and Air Monitoring
Local Exhaust System

SD-07 Certificates

Local Exhaust System
Encapsulants; G
Medical Surveillance Requirements

1.5 QUALITY ASSURANCE

In addition to detailed requirements of this specification, work performed under this contract shall comply with EM 385-1-1, applicable ROK national, provincial, and local laws including Act No. 10389, MD No. 406, and PD No. 22631, ordinances, criteria, rules and regulations regarding handling, storing, transporting, and disposing of asbestos waste materials. Matters of interpretation of standards shall be submitted to the appropriate administrative agency for resolution before starting work. Where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply.

1.5.1 Written Qualifications and Organization Report

Submit a written qualifications and organization report providing evidence of qualifications of the Contractor, Contractor's Project Supervisor, Designated Competent Person, supervisors and workers; Designated Industrial Hygienist (IH); independent testing laboratory; all subcontractors to be used including disposal transportation and disposal facility firms, subcontractor supervisors, subcontractor workers; and any others assigned to perform asbestos abatement and support activities. Include in the report an organization chart showing the Contractor's staff organization chain of command and reporting relationship with all subcontractors. The report shall be signed by the Contractor, the Contractor's onsite project manager, Designated Competent Person, Designated IH, designated testing laboratory and the principals of all subcontractors to be used. Include the following statement in the report: "By signing this report I certify that the personnel I am responsible for during the course of this project fully understand the contents of 29 CFR 1926.1101, 40 CFR 61, Subpart M, and the local requirements for those asbestos abatement activities that they will be involved in."

1.5.2 Specific Requirements

Designate in writing, personnel meeting the following qualifications:

a. Asbestos Abatement Contractor: Certified/licensed to perform asbestos-related activities.

b. Designated Competent Person: Qualified in accordance with 29 CFR 1926.32 and 29 CFR 1926.1101, has EPA MAP "Contractor/Supervisor" training accreditation, has EPA certification/license as a "Contractor/Supervisor" and is experienced in the administration and supervision of asbestos abatement projects The Designated Competent Person shall be responsible for compliance with USFK Reg 201-1 and applicable local requirements, the Contractor's Accident Prevention Plan (APP) and Asbestos Hazard Abatement Plan (AHAP). Submit the "Contractor/Supervisor" course completion certificate and the most recent certificate for required refresher training, EPA certification/license with the employee "Certificate of Worker Acknowledgment". Submit evidence that this person has a minimum of 2 years of on-the-job asbestos abatement experience relevant to OSHA competent person requirements. The Designated Competent Person shall be onsite at all times during the conduct of this project.

c. Project and Other Supervisors: Have EPA MAP "Contractor/Supervisor" training accreditation. Submit the "Contractor/Supervisor" course completion certificate and the most recent certificate for required refresher training, EPA certification/license with the employee "Certificate of Worker Acknowledgment". Also submit evidence that the Project Supervisor has a minimum of 2 years of on-the-job asbestos abatement experience relevant to project supervisor responsibilities and the other supervisors have a minimum of 1 year on-the-job asbestos abatement experience commensurate with the responsibilities they will have on this project.

d. Designated Industrial Hygienist: Resume for the Industrial Hygienist (IH) selected to prepare the Contractor's AHAP, prepare and perform training, direct air monitoring and assist the Contractor's Competent Person in implementing and ensuring that safety and health requirements are complied with during the performance of all required work. The Designated IH shall be a person who is board certified in the practice of industrial hygiene or board eligible (meets all education and experience requirements) as determined and documented by the American Board of Industrial Hygiene (ABIH), has EPA MAP "Contractor/Supervisor" training accreditation, has EPA certification/license, and has a minimum of 2 years of comprehensive experience in planning and overseeing asbestos abatement activities. Submit the "Contractor/Supervisor" course completion certificate and the most recent certificate for required refresher training and EPA/State certification/license with the employee "Certificate of Worker Acknowledgment". The Designated IH shall be completely independent from the Contractor according to federal, state, or local regulations; that is, shall not be a Contractor's employee or be an employee or principal of a firm in a business relationship with the Contractor negating such independent status. A copy of the Designated IH's current valid ABIH certification or confirmation of eligibility in writing from the ABIH shall be included. In addition, submit resumes of additional IH's and industrial hygiene technicians (IHT) who will be assisting the Designated IH in performing onsite tasks. IH and IHT supporting the Designated IH shall have a minimum of 2 years of practical onsite asbestos abatement experience. Indicate the formal reporting relationship between the Designated IH and the support IH and IHT, the Designated Competent Person, and the Contractor.

e. Asbestos Abatement Workers: Meet the requirements contained in USFK Reg 201-1. Worker training documentation shall be provided as required on the "Certificate of Workers Acknowledgment". Training documentation is required for each employee who will perform OSHA Class I, Class II, Class III, or Class IV asbestos abatement operations. Such documentation shall be submitted on a Contractor generated form titled "Certificate of Workers Acknowledgment", to be completed for each employee in the same format and containing the same information as the example certificate at the end of this section. Training course completion certificates (initial and most recent update refresher) required by the information checked on the form shall be attached.

f. Physician: Resume of the physician who will or has performed the medical examinations and evaluations of the persons who will conduct the asbestos abatement work tasks. The physician shall be currently licensed by the state where the workers will be or have been examined, have expertise in pneumoconiosis and shall be responsible for the determination of medical surveillance protocols and for review of examination/test results performed in compliance with 29 CFR 1926.1101. The physician shall be familiar with the site's hazards and the scope of this project.

g. Independent Testing Laboratory: identify the independent testing laboratory selected to perform the sample analyses and report the results. The testing laboratory shall be completely independent from the Contractor. Written verification of the following criteria, signed by the testing laboratory principal and the Contractor, shall be submitted:

(1) Phase contrast microscopy (PCM): The laboratory is fully equipped and proficient in conducting PCM of airborne samples using the methods specified by 29 CFR 1926.1101, OSHA method ID-160, the most current version of NIOSH 94-113 Method 7400. The laboratory shall be currently judged proficient (classified as acceptable) in counting airborne asbestos samples by PCM by successful participation in each of the last 4 rounds in the American Industrial Hygiene Association (AIHA) Proficiency Analytical Testing (PAT) Program or by participating in the AIHA PAT Program, and being judged proficient in counting samples.

(2) Polarized light microscopy (PLM): The laboratory is fully equipped and proficient in conducting PLM analyses of suspect ACM bulk samples in accordance with 40 CFR 763, Subpart E, Appendix E; the laboratory is currently accredited by NIST under the NVLAP for bulk asbestos analysis and will use analysts with demonstrated proficiency to conduct PLM analyses.

(3) Transmission electron microscopy (TEM): The laboratory is proficient in conducting analysis for low asbestos concentration, enhanced analysis of floor tiles and bulk materials where multiple layers are present, using an improved EPA test method titled, "Method for the Determination of Asbestos in Bulk Building Materials".

(4) PCM/TEM: The laboratory is fully equipped and each analyst is proficient in conducting PCM and TEM analysis of airborne samples using NIOSH 94-113 Method 7400 PCM and NIOSH 94-113 Method 7402 (TEM confirmation of asbestos content of PCM results) from the same filter.

h. Disposal Facility, Transporter: Written evidence that the landfill to be used is approved for asbestos disposal by the local regulatory agencies. Copies of signed agreements between the Contractor (including subcontractors and transporters) and the asbestos waste disposal facility to accept and dispose of all asbestos containing waste shall be provided. The Contractor and transporters shall meet ROK national, provincial, and local requirements in accordance with USFK Reg 201-1. The disposal facility shall meet local requirements.

1.5.3 Preconstruction Conference

The Contractor and the Contractor's Designated Competent Person, Project Supervisor, and Designated IH shall meet with the Contracting Officer (CO) prior to beginning work at a safety preconstruction conference to discuss the details of the Contractor's submitted APP to include the AHAP and AHA appendices. Deficiencies in the APP will be discussed. Onsite work shall not begin until the APP has been accepted.

1.6 SAFETY

Prepare a written comprehensive site-specific Accident Prevention Plan (APP) at least 30 days prior to the preconstruction conference. The APP shall be in accordance with the format and requirements in Appendix A of EM 385-1-1. The APP shall incorporate an Asbestos Hazard Abatement Plan (AHAP), and Activity Hazard Analyses (AHA) as separate appendices into one site-specific document. The APP shall take into consideration all the individual asbestos abatement work tasks. See Section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS for additional requirements.

1.6.1 Asbestos Hazard Abatement Plan Appendix

The AHAP shall include, but not be limited to, the following:

a. The personal protective equipment to be used;

b. The location and description of regulated areas including clean and dirty areas, and decontamination unit (clean room, shower room, equipment room, storage areas such as load-out unit);

c. Initial exposure assessment in accordance with 29 CFR 1926.1101;

d. Level of supervision;

e. Method of notification of other employers at the worksite;

f. Abatement method to include containment and control procedures;

g. Interface of trades;

h. Sequencing of asbestos related work;

i. Storage and disposal procedures and plan;

j. Type of wetting agent and asbestos encapsulant;

k. Location of local exhaust equipment;

l. Air monitoring methods (personal, environmental and clearance);

m. Bulk sampling and analytical methods (if required);

n. A detailed description of the method to be employed in order to control the spread of ACM wastes and airborne fiber;

o. Fire and medical emergency response procedures;

p. The security procedures to be used for all regulated areas.

1.6.2 Activity Hazard Analyses Appendix

AHA for each major phase of work, shall be submitted and updated during the project. The AHA format shall be in accordance with Figure 1-1 of EM 385-1-1. The analysis shall define the activities to be performed for a major phase of work, identify the sequence of work, the specific hazards anticipated, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level. Work shall not proceed on that phase until the AHA has been accepted and a preparatory meeting has been conducted by the Contractor to discuss its contents with everyone engaged in the activities, including the onsite Government representatives. The AHA shall be continuously reviewed and, when appropriate, modified to address changing site conditions or operations.

1.6.3 Local Exhaust System

Local exhaust units shall conform to AIHA Z9.2 and 29 CFR 1926.1101. Filters on local exhaust system equipment shall conform to AIHA Z9.2 and UL 586. Filter shall be UL labeled. Submit pressure differential recordings and Manufacturer's certifications showing compliance with AIHA Z9.2 for:

a. Vacuums.
b. Water filtration equipment.
c. Ventilation equipment.
d. Other equipment required to contain airborne asbestos fibers.

1.7 SECURITY

Fenced and locked security area shall be provided for each regulated area. A log book shall be kept documenting entry into and out of the regulated area. Entry into regulated areas shall only be by personnel authorized by the Contractor and the CO. Personnel authorized to enter regulated areas shall be trained, medically evaluated, and wear the required personal protective equipment.

1.7.1 Licenses, Permits and Notifications

Obtain necessary licenses, permits and notifications in conjunction with the project's asbestos abatement, transportation and disposal actions and timely notification furnished of such actions as required by federal, state, regional, and local authorities. The Contractor shall notify the local air pollution control district/agency and the Contracting Officer in writing, at least 10 days prior to the commencement of work, in accordance with 40 CFR 61, Subpart M, and state and local requirements to include the mandatory "Notification of Demolition and Renovation Record" form and other required notification documents. Contractor shall notify local fire department 3 days before fireproofing material is removed from a building and the notice shall specify whether or not the material contains asbestos. Contractor shall also notify the local Directorate of Public Works, Environmental Division or Air Force Civil Engineering Squadron at least seven calendar days prior to beginning asbestos removal work of any kind. The Contractor is responsible for the associated fees/costs for licenses, permits, and notifications.

1.7.2 Regulated Areas

All Class I, II, and III asbestos work shall be conducted within regulated areas. The regulated area shall be demarcated to minimize the number of persons within the area and to protect persons outside the area from exposure to airborne asbestos. Control access to regulated areas, ensure that only authorized personnel enter, and verify that Contractor required medical surveillance, training and respiratory protection program requirements are met prior to allowing entrance.

1.7.3 Warning Signs and Tape

Warning signs and tape printed bilingually in English and Korean shall be provided at the regulated boundaries and entrances to regulated areas. Signs shall be located to allow personnel to read the signs and take the necessary protective steps required before entering the area. Warning signs, and displaying the following legend in the lower panel:

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

1.7.4 Warning Labels

Warning labels shall be affixed to all asbestos disposal containers, asbestos materials, scrap, waste debris, and other products contaminated with asbestos. Containers with preprinted warning labels conforming to requirements are acceptable.

1.8 MEDICAL SURVEILLANCE REQUIREMENTS

Medical surveillance requirements shall conform to 29 CFR 1926.1101. Asbestos workers shall be enrolled in a medical surveillance program that meets 29 CFR 1926.1101 (m) requirements. This requirement shall have been satisfied within the last 12 months. Submit required medical certification and the Physician's written opinion.

1.8.1 Respiratory Protection Program

The Contractor shall establish in writing, and implement a respiratory protection program in accordance with 29 CFR 1926.1101 and 29 CFR 1910.134. The Contractor shall establish minimum respiratory protection requirements based on measured or anticipated levels of airborne asbestos fiber concentrations.

1.8.2 Respiratory Fit Testing

The Contractor shall conduct a qualitative or quantitative fit test conforming to Appendix A of 29 CFR 1910.134 for each worker required to wear a respirator, and any authorized visitors who enter a regulated area where respirators are required to be worn. A respirator fit test shall be performed prior to initially wearing a respirator and every 12 months thereafter. If physical changes develop that will affect the fit, a new fit test shall be performed. Functional fit checks shall be performed each time a respirator is put on and in accordance with the manufacturer's recommendation.

1.8.3 Respirator Selection and Use Requirements

Provide respirators, and ensure that they are used as required by

29 CFR 1926.1101 and in accordance with CGA G-7 and the manufacturer's recommendations. Respirators shall be approved by the National Institute for Occupational Safety and Health NIOSH, under the provisions of 42 CFR 84, for use in environments containing airborne asbestos fibers. The initial respirator selection and the decisions regarding the upgrading or downgrading of respirator type shall be made by the Contractor's Designated IH based on the measured or anticipated airborne asbestos fiber concentrations to be encountered.

1.8.4 Personal Protective Equipment

Three complete sets of personal protective equipment shall be made available to the CO and authorized visitors for entry to the regulated area. The CO and authorized visitors shall be provided with training equivalent to that provided to Contractor employees in the selection, fitting, and use of personal protective equipment and the site safety and health requirements. Provide workers with personal protective clothing and equipment and ensure that it is worn properly. The Designated IH and Designated Competent Person shall select and approve all the required personal protective clothing and equipment.

1.8.5 Whole Body Protection

Personnel exposed to or having the potential to be exposed to airborne concentrations of asbestos that exceed the PELs, or for all OSHA Classes of work for which a required negative exposure assessment is not produced, shall be provided with whole body protection and such protection shall be worn properly. Disposable whole body protection shall be disposed of as asbestos contaminated waste upon exiting from the regulated area. Reusable whole body protection worn shall be either disposed of as asbestos contaminated waste upon exiting from the regulated area or be properly laundered in accordance with 29 CFR 1926.1101. The Contractor's Designated Competent Person, in consultation with the Designated IH, has the authority to take immediate action to upgrade or downgrade whole body protection when there is an immediate danger to the health and safety of the wearer.

1.8.5.1 Coveralls

Disposable-impermeable coveralls with a zipper front shall be provided. Sleeves shall be secured at the wrists, and foot coverings secured at the ankles.

1.8.5.2 Gloves

Gloves shall be provided to protect the hands where there is the potential for hand injuries (i.e., scrapes, punctures, cuts, etc.).

1.8.5.3 Foot Coverings

Cloth socks shall be provided and worn next to the skin. Footwear, as required by OSHA and EM 385-1-1, that is appropriate for safety and health hazards in the area shall be worn. Reusable footwear removed from the regulated area shall be thoroughly decontaminated or disposed of as ACM waste.

1.8.5.4 Head Covering

Hood type disposable head covering shall be provided. In addition, protective head gear (hard hats) shall be provided as required. Hard hats shall only be removed from the regulated area after being thoroughly decontaminated.

1.8.5.5 Protective Eye Wear

Eye protection shall be provided, when operations present a potential eye injury hazard, and shall meet the requirements of ASSE/SAFE Z87.1.

1.9 HYGIENE

Establish a decontamination area for the decontamination of employees, material and equipment. Ensure that employees enter and exit the regulated area through the decontamination area.

1.9.1 3-Stage Decontamination Area

The decontamination unit shall have an equipment room and a clean room separated by a shower that complies with 29 CFR 1910.141, unless the Contractor can demonstrate that such facilities are not feasible. Equipment and surfaces of containers filled with ACM shall be cleaned prior to removing them from the equipment room or area. Two separate lockers shall be provided for each asbestos worker, one in the equipment room and one in the clean room. Wastewater shall be collected and filtered to remove asbestos contamination. Filters and residue shall be disposed of as asbestos contaminated material Wastewater filters shall be installed in series with the first stage pore size of 20 microns and the second stage pore size of 5 microns. The floor of the decontamination unit's clean room shall be kept dry and clean at all times. Proper housekeeping and hygiene requirements shall be maintained. Soap and towels shall be provided for showering, washing and drying. Any cloth towels provided shall be disposed of as ACM waste or shall be laundered in accordance with 29 CFR 1926.1101.

1.9.2 Load-Out Unit

A temporary load-out unit that is adjacent and connected to the regulated area shall be provided . The load-out unit shall be attached in a leak-tight manner to each regulated area.

1.9.3 Single Stage Decontamination Area

A decontamination area (equipment room/area) shall be provided for Class I work involving less than 7.5 m (25 feet) or 0.9 square meters (10 square feet) of TSI or surfacing ACM, and for Class II and Class III asbestos work operations where exposures exceed the PELs or where there is no negative exposure assessment. The equipment room or area shall be adjacent to the regulated area for the decontamination of employees, material, and their equipment which could be contaminated with asbestos. The area shall be covered by an impermeable drop cloth on the floor or horizontal working surface. The area must be of sufficient size to accommodate cleaning of equipment and removing personal protective equipment without spreading contamination beyond the area.

1.9.4 Decontamination Area Exit Procedures

Ensure that the following procedures are followed:

a. Before leaving the regulated area, remove all gross contamination and debris from work clothing using a HEPA vacuum.

b. Employees shall remove their protective clothing in the equipment room and deposit the clothing in labeled impermeable bags or containers for disposal and/or laundering.

c. Employees shall not remove their respirators until showering.

d. Employees shall shower prior to entering the clean room. If a shower has not been located between the equipment room and the clean room or the work is performed outdoors, ensure that employees engaged in Class I asbestos jobs: a) Remove asbestos contamination from their work suits in the equipment room or decontamination area using a HEPA vacuum before proceeding to a shower that is not adjacent to the work area; or b) Remove their contaminated work suits in the equipment room, without cleaning work suits, and proceed to a shower that is not adjacent to the work area.

1.9.5 Smoking

Smoking, if allowed by the Contractor, shall only be permitted in designated areas approved by the CO.

1.10 TRAINING PROGRAM

Establish and submit a training program as specified by EPA MAP, training requirements at 40 CFR 763, OSHA requirements at 29 CFR 1926.1101 (k)(9). Contractor employees shall complete the required training for the type of work they are to perform and such training shall be documented and provided to the CO.

a. Class I and II operations 32 hours Asbestos Worker Training
b. Class II generic removal 8 hour Asbestos Worker Training
c. Class III operations 16 hour O & M Training
d. Class IV operations 2 hour Awareness Training

Prior to commencement of work the Contractor's Designated IH and Competent Person shall instruct each worker about:

a. The hazards and health effects of the specific types of ACM to be abated; and

b. The content and requirements of the Contractor's APP to include the AHAP and AHA and site-specific safety and health precautions.

PART 2 PRODUCTS

2.1 ENCAPSULANTS

Encapsulants shall conform to US EPA requirements, shall contain no toxic or hazardous substances and no solvent. Submit certificates stating that encapsulants meet the applicable specified performance requirements.

2.2 EXPENDABLE SUPPLIES

2.2.1 Glove bag

Glove bags shall be provided as described in 29 CFR 1926.1101. The glove bag assembly shall be 0.15 mm (6 mil) thick plastic, prefabricated and seamless at the bottom with preprinted OSHA warning label.

2.2.2 Duct Tape

Industrial grade duct tape of appropriate widths suitable for bonding sheet plastic and disposal container.

2.2.3 Disposal Containers

Leak-tight (defined as solids, liquids, or dust that cannot escape or spill out) disposal containers shall be provided for ACM wastes as required by 29 CFR 1926.1101 . Disposal containers can be in the form of:

a. Disposal Bags

b. Fiberboard Drums

c. Cardboard Boxes

2.2.4 Sheet Plastic

Sheet plastic shall be polyethylene of 0.15 mm (6 mil) minimum thickness and shall be provided in the largest sheet size necessary to minimize seams Film shall be clear, frosted or black and conform to ASTM D 4397 or KS T 1093, except as specified below:

2.2.4.1 Flame Resistant

Where a potential for fire exists, flame-resistant sheets shall be provided. Film shall be frosted or black and shall conform to the requirements of NFPA 701.

2.2.4.2 Reinforced

Reinforced sheets shall be provided where high skin strength is required, such as where it constitutes the only barrier between the regulated area and the outdoor environment. The sheet stock shall consist of translucent, nylon-reinforced or woven-polyethylene thread laminated between 2 layers of polyethylene film. Film shall meet flame resistant standards of NFPA 701.

2.2.5 Mastic Removing Solvent

Mastic removing solvent shall be nonflammable and shall not contain methylene chloride, glycol ether, or halogenated hydrocarbons. Solvents used onsite shall have a flash point greater than 60 degrees C (140 degrees F).

2.2.6 Leak-tight Wrapping

Two layers of 0.15 mm (6 mil) minimum thick polyethylene sheet stock shall be used for the containment of removed asbestos-containing components or materials such as reactor vessels, large tanks, boilers, insulated pipe segments and other materials too large to be placed in disposal bags . Upon placement of the ACM component or material, each layer shall be individually leak-tight sealed with duct tape.

2.2.7 Viewing Inspection Window

Where feasible, a minimum of 1 clear, 3 mm (1/8 inch) thick, acrylic sheet, 450 by 610 mm (18 by 24 inches), shall be installed as a viewing inspection window at eye level on a wall in each containment enclosure. The windows shall be sealed leak-tight with industrial grade duct tape.

2.2.8 Wetting Agents

Amended water shall meet the requirements of ASTM D 1331. Removal encapsulant (a penetrating encapsulant) shall be provided when conducting removal abatement activities that require a longer removal time or are subject to rapid evaporation of amended water. The removal encapsulant shall be capable of wetting the ACM and retarding fiber release during disturbance of the ACM greater than or equal to that provided by amended water. Performance requirements for penetrating encapsulants are specified in paragraph ENCAPSULANTS above.

2.2.9 Strippable Coating

Strippable coating in aerosol cans shall be used to adhere to surfaces and to be removed cleanly by stripping, at the completion of work.

2.3 EQUIPMENT

2.3.1 Scales

Scales used for measurement shall be public scales. Weighing shall be at a point nearest the work at which a public scale is available. Scales shall be standard truck scales of the beam type; scales shall be equipped with the type registering beam and an "over and under" indicator; and shall be capable of accommodating the entire vehicle. Scales shall be calibrated and resealed as often as necessary and at least once every three months to ensure continuous accuracy. Vehicles used for hauling ACM shall be weighed empty daily at such time as directed and each vehicle shall bear a plainly legible identification mark.

2.3.2 Tools

Vacuums shall be equipped with HEPA filters, of sufficient capacity and necessary capture velocity at the nozzle or nozzle attachment to efficiently collect, transport and retain the ACM waste material. Power tools shall not be used to remove ACM unless the tool is equipped with effective, integral HEPA filtered exhaust ventilation capture and collection system. Reusable tools shall be thoroughly decontaminated prior to being removed from regulated areas.

2.3.3 Rental Equipment

If rental equipment is to be used, written notification shall be provided to the rental agency, concerning the intended use of the equipment, the possibility of asbestos contamination of the equipment and the steps that will be taken to decontaminate such equipment.

2.3.4 Air Monitoring Equipment

The Contractor's Designated IH shall approve air monitoring equipment. The equipment shall include, but shall not be limited to:

a. High-volume sampling pumps that can be calibrated and operated at a constant airflow up to 16 liters per minute.

b. Low-volume, battery powered, body-attachable, portable personal pumps that can be calibrated to a constant airflow up to approximately 3.5 liters per minute, and a self-contained rechargeable power pack capable of sustaining the calibrated flow rate for a minimum of 10 hours. The pumps shall also be equipped with an automatic flow control unit which shall maintain a constant flow, even as filter resistance increases due to accumulation of fiber and debris on the filter surface.

c. Single use standard 25 mm diameter cassette, open face, 0.8 micron pore size, mixed cellulose ester membrane filters and cassettes with 50 mm electrically conductive extension cowl, and shrink bands for personal air sampling.

d. Single use standard 25 mm diameter cassette, open face, 0.45 micron pore size, mixed cellulose ester membrane filters and cassettes with 50 mm electrically conductive cowl, and shrink bands when conducting environmental area sampling using NIOSH 94-113 Methods 7400 and 7402, (and the transmission electric microscopy method specified at 40 CFR 763 if required).

e. A flow calibrator capable of calibration to within plus or minus 2 percent of reading over a temperature range of minus 20 to plus 60 degrees C (minus 4 to plus 140 degrees F) and traceable to a NIST primary standard.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Asbestos abatement work tasks shall be performed as shown on the detailed plans Use the engineering controls and work practices required in 29 CFR 1926.1101(g) in all operations regardless of the levels of exposure. Personnel shall wear and utilize protective clothing and equipment. Do not permit eating, smoking, drinking, chewing or applying cosmetics in the regulated area. Personnel of other trades, shall not be exposed at any time to airborne concentrations of asbestos unless all the administrative and personal protective provisions of the Contractor's APP are complied with. Power to the regulated area shall be locked-out and tagged in accordance with 29 CFR 1910.147, and temporary electrical service with ground fault circuit interrupters shall be provided as needed. Temporary electrical service shall be disconnected when necessary for wet removal. Stop abatement work in the regulated area immediately when the airborne total fiber concentration: (1) equals or exceeds 0.01 f/cc, or the pre-abatement concentration, whichever is greater, outside the regulated area; or (2) equals or exceeds 1.0 f/cc inside the regulated area. Correct the condition to the satisfaction of the CO, including visual inspection and air sampling. Work shall resume only upon notification by the CO. Corrective actions shall be documented.

3.2 PROTECTION OF ADJACENT WORK OR AREAS TO REMAIN

Perform asbestos abatement without damage to or contamination of adjacent work or area. Where such work or area is damaged or contaminated, it shall be restored to its original condition or decontaminated at no expense to the Government. When spills occur, work shall stop in all affected areas immediately and the spill shall be cleaned. When satisfactory visual inspection and air sampling analysis results are obtained and have been evaluated by the Contractor's Designated IH and the CO, work shall proceed.

3.3 OBJECTS

3.3.1 Removal of Mobile Objects

The Government will remove Furniture, and equipment from the area of work before work begins.

3.3.2 Stationary Objects

Stationary objects, furniture, and equipment as shown on EP 1110-1-11 Setup DETAIL SHEET 27, shall remain in place and shall be precleaned using HEPA vacuum followed by adequate wet wiping. Stationary objects and furnishings shall be covered with 2 layers of polyethylene and edges sealed with duct tape.

3.4 BUILDING VENTILATION SYSTEM AND CRITICAL BARRIERS

Building ventilation system supply and return air ducts in a regulated area shall be shut down and isolated by lockable switch or other positive means in accordance with 29 CFR 1910.147. The airtight seals shall consist of air-tight rigid covers for building ventilation supply and exhaust grills where the ventilation system is required to remain in service during abatement or 2 layers of polyethylene. Edges to wall, ceiling and floor surfaces shall be sealed with industrial grade duct tape.

3.5 PRECLEANING

Surfaces shall be cleaned by HEPA vacuum and adequately wet wiped prior to establishment of containment.

3.6 METHODS OF COMPLIANCE

3.6.1 Mandated Practices

The specific abatement techniques and items identified shall be detailed in the Contractor's AHAP. Use the following engineering controls and work practices in all operations, regardless of the levels of exposure:

a. Vacuum cleaners equipped with HEPA filters.

b. Wet methods or wetting agents except where it can be demonstrated that the use of wet methods is unfeasible due to the creation of electrical hazards, equipment malfunction, and in roofing.

c. Prompt clean-up and disposal.

d. Inspection and repair of polyethylene.

e. Cleaning of equipment and surfaces of containers prior to removing them from the equipment room or area.

3.6.2 Control Methods

Use the following control methods:

a. Local exhaust ventilation equipped with HEPA filter;

b. Enclosure or isolation of processes producing asbestos dust;

c. Where the feasible engineering and work practice controls are not sufficient to reduce employee exposure to or below the PELs, use them to reduce employee exposure to the lowest levels attainable and shall supplement them by the use of respiratory protection.

3.6.3 Unacceptable Practices

The following work practices shall not be used:

a. High-speed abrasive disc saws that are not equipped with point of cut ventilator or enclosures with HEPA filtered exhaust air.

b. Compressed air used to remove asbestos containing materials, unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the dust cloud created by the compressed air.

c. Dry sweeping, shoveling, or other dry clean up.

d. Employee rotation as a means of reducing employee exposure to asbestos.

3.6.4 Class I Work Procedures

In addition to requirements of paragraphs Mandated Practices and Control Methods, the following engineering controls and work practices shall be used:

a. A Competent Person shall supervise the installation and operation of the control methods.

b. For jobs involving the removal of more than 7.5 m (25 feet) or 0.9 square m (10 square feet) of TSI or surfacing material, place critical barriers over all openings to the regulated area.

c. HVAC systems shall be isolated in the regulated area by sealing with a double layer of plastic or air-tight rigid covers.

d. Impermeable drop cloths (0.15 mm (6 mil) or greater thickness) shall be placed on surfaces beneath all removal activity.

e. Where a negative exposure assessment has not been provided or where exposure monitoring shows the PEL was exceeded, the regulated area shall be ventilated with a HEPA unit and employees must use PPE.

3.6.5 Specific Control Methods for Class I Work

3.6.5.1 Negative Pressure Enclosure (NPE) System

The NPE system shall provide at least 4 air changes per hour inside the containment. The local exhaust unit equipment shall be operated 24 hours per day until the containment is removed. The NPE shall be smoke tested for leaks at the beginning of each shift and be sufficient to maintain a minimum pressure differential of minus 0.5 mm (0.02 inch) of water column relative to adjacent, unsealed areas. Pressure differential shall be monitored continuously, 24 hours per day, with an automatic manometric recording instrument and Records shall be provided daily on the same day collected to the CO. The CO shall be notified immediately if the pressure differential falls below the prescribed minimum. The building ventilation system shall not be used as the local exhaust system for the regulated area. The NPE shall terminate outdoors unless an alternate arrangement is allowed by the CO. All filters used shall be new at the beginning of the project and shall be periodically changed as necessary and disposed of as ACM waste.

3.6.5.2 Glove bag Systems

Glove bags shall be used without modification, smoke-tested for leaks, and completely cover the circumference of pipe or other structures where the work is to be done. Glove bags shall be used only once and shall not be moved. Glove bags shall not be used on surfaces that have temperatures exceeding 66 degrees C (150 degrees F). Prior to disposal, glove bags shall be collapsed using a HEPA vacuum. Before beginning the operation, loose and friable material adjacent to the glove bag operation shall be wrapped and sealed in 2 layers of plastic or otherwise rendered intact. At least 2 persons shall perform glove bag removal. Asbestos regulated work areas shall be established as shown on detailed drawings and plans for glove bag abatement. Designated boundary limits for the asbestos work shall be established with rope or other continuous barriers and all other requirements for asbestos control areas shall be maintained, including area signage and boundary warning tape .

a. Attach HEPA vacuum systems to the bag to prevent collapse during removal of ACM.

b. The negative pressure glove boxes shall be fitted with gloved apertures and a bagging outlet and constructed with rigid sides from metal or other material which can withstand the weight of the ACM and water used during removal. A negative pressure shall be created in the system using a HEPA filtration system. The box shall be smoke tested for leaks prior to each use.

3.6.5.3 Mini-Enclosures

Mini-containment (small walk-in enclosure) to accommodate no more than 2 persons, may be used if the disturbance or removal can be completely contained by the enclosure. The mini-enclosure shall be inspected for leaks and smoke tested before each use. Air movement shall be directed away from the employee's breathing zone within the mini-enclosure.

3.6.5.4 Wrap and Cut Operation

Prior to cutting pipe, the asbestos-containing insulation shall be wrapped with polyethylene and securely sealed with duct tape to prevent asbestos becoming airborne as a result of the cutting process. The following steps shall be taken: install glove bag, strip back sections to be cut 150 mm (6 inches) from point of cut, and cut pipe into manageable sections.

3.6.6 Class II Work

In addition to the requirements of paragraphs Mandated Practices and Control Methods, the following engineering controls and work practices shall be used:

a. A Competent Person shall supervise the work.

b. For indoor work, critical barriers shall be placed over all openings to the regulated area.

c. Impermeable drop cloths shall be placed on surfaces beneath all removal activity.

3.6.7 Specific Control Methods for Class II Work

3.6.7.1 Vinyl and Asphalt Flooring Materials

When removing vinyl and asphalt flooring materials which contain ACM, use the following practices . Resilient sheeting shall be removed by adequately wet methods. Tiles shall be removed intact (if possible); wetting is not required when tiles are heated and removed intact. Flooring or its backing shall not be sanded. Scraping of residual adhesive and/or backing shall be performed using wet methods. Mechanical chipping is prohibited unless performed in a negative pressure enclosure. Dry sweeping is prohibited. Use vacuums equipped with HEPA filter, disposable dust bag, and metal floor tool (no brush) to clean floors.

3.6.7.2 Roofing Material

When removing roofing materials which contain ACM as described in 29 CFR 1926.1101(g)(8)(ii), use the following practices . Roofing material shall be removed in an intact state. Wet methods shall be used to remove roofing materials that are not intact, or that will be rendered not intact during removal, unless such wet methods are not feasible or will create safety hazards. When removing built-up roofs, with asbestos-containing roofing felts and an aggregate surface, using a power roof cutter, all dust resulting from the cutting operations shall be collected by a HEPA dust collector, or shall be HEPA vacuumed by vacuuming along the cut line. Asbestos-containing roofing material shall not be dropped or thrown to the ground, but shall be lowered to the ground via covered, dust-tight chute, crane, hoist or other method approved by the CO. Any ACM that is not intact shall be lowered to the ground as soon as practicable, but not later than the end of the work shift. While the material remains on the roof it shall be kept wet or placed in an impermeable waste bag or wrapped in plastic sheeting. Intact ACM shall be lowered to the ground as soon as practicable, but not later than the end of the work shift. Unwrapped material shall be transferred to a closed receptacle. Critical barriers shall be placed over roof level heating and ventilation air intakes.

3.6.7.3 Cementitious Siding and Shingles or Transite Panels

When removing cementitious asbestos-containing siding, shingles or transite panels use the following work practices . Intentionally cutting, abrading or breaking is prohibited. Each panel or shingle shall be sprayed with amended water prior to removal. Nails shall be cut with flat, sharp instruments. Unwrapped or unbagged panels or shingles shall be immediately lowered to the ground via covered dust-tight chute, crane or hoist, or placed in an impervious waste bag or wrapped in plastic sheeting and lowered to the ground no later than the end of the work shift.

3.6.7.4 Gaskets

Gaskets shall be thoroughly wetted with amended water prior to removal and immediately placed in a disposal container. If a gasket is visibly deteriorated and unlikely to be removed intact, removal shall be undertaken within a glove bag. Any scraping to remove residue shall be performed wet.

3.6.8 Specific Control Methods for Class III Work

Class III asbestos work shall be conducted using engineering and work practice controls which minimize the exposure to employees performing the asbestos work. The work shall be performed using wet methods and, to the extent feasible, using local exhaust. Use impermeable drop cloths and shall isolate the operation, using mini-enclosures or glove bag systems, where the disturbance involves drilling, cutting, abrading, sanding, chipping, breaking, or sawing of TSI or surfacing material.

3.6.9 Specific Control Methods for Class IV Work

Class IV jobs shall be conducted using wet methods and HEPA vacuums. Employees cleaning up debris and waste in a regulated area where respirators are required shall wear the selected respirators.

3.6.10 Methods for Asphaltic Wrap

Removal or disturbance of pipeline asphaltic wrap shall be performed using wet methods.

3.6.11 Abatement of Asbestos Contaminated Soil

Asbestos contaminated soil shall be removed from areas to a minimum depth of 50 mm (2 inches). Soil shall be thoroughly dampened with amended water and then removed by manual shoveling into labeled containers. The Contractor has the option to propose encapsulation of soil instead of removal. Since soil encapsulation is highly dependent on soil chemistry, available skills for application and proprietary products, first test the proposed soil encapsulant on a minimum 9.3 square meter (100 square feet) of soil area onsite. The test shall be witnessed by the CO and the manufacturer's representative. A written application for encapsulation shall be submitted to the CO with test results, encapsulant manufacturer's positive recommendation for use, a guarantee for satisfactory performance for 10 years, and limitation of application. If the application is accepted, the soil encapsulation shall proceed in compliance with all provisions and instructions of the encapsulant manufacturer and under the supervision of a person certified by the manufacturer who is trained and experienced in the proper application of the soil encapsulant. A concrete slab of minimum 50 mm (2 inch) thickness shall be poured over the entire soil surface. Soil surface shall be thoroughly dampened before pouring concrete. Soil encapsulators and supervisors shall be primarily concrete workers trained to work in asbestos contaminated environments.

3.6.12 Enclosure of ACM

Isolation of ACM by construction of a permanent enclosure shall be conducted.

3.6.13 Encapsulation of ACM

Prior to applying any encapsulant, the entire surface area shall be inspected for loose, or damaged asbestos material:

a. Penetrating Encapsulation: Before penetrating encapsulation is applied, asbestos removal work in the area shall be complete. Substrate shall be evaluated before application to ensure that the encapsulant will not cause the substrate to fail in any way. Plug samples shall be taken to determine if full penetration has been achieved. If full penetration has not been achieved, surfaces shall be recoated while the matrix is still wet, until full penetration is achieved:

b. Bridging Encapsulation: The surface shall be encapsulated in sections of 93 square m (1000 square feet) or less as recommended by the encapsulant manufacturer. Upon completion of each section, the dry thickness of the bridging encapsulation shall be measured. Additional bridging encapsulant shall be applied to obtain the desired encapsulant thickness. Additional coats shall blend with the original bridging encapsulant.

3.6.14 Combined Encapsulation of Acoustical Wall and Ceiling Plaster

The combination penetrating/bridging encapsulation system shall be installed by first applying the penetrating encapsulant and then the bridging encapsulant:

3.6.15 Sealing Contaminated Items Designated for Disposal

Contaminated items designated for removal shall be coated with an asbestos lockdown encapsulant before being removed from the asbestos control area. The asbestos lockdown encapsulant shall be tinted a contrasting color and shall be spray applied by airless method. Thoroughness of sealing operation shall be visually gauged by the extent of colored coating on exposed surfaces.

3.7 FINAL CLEANING AND VISUAL INSPECTION

After completion of all asbestos removal work and the gross amounts of asbestos have been removed from every surface, any remaining visible accumulations of asbestos shall be collected. For all classes of indoor asbestos abatement projects a final cleaning shall be performed using HEPA vacuum and wet cleaning of all exposed surfaces and objects in the regulated area. Upon completion of the cleaning, conduct a visual pre-inspection of the cleaned area in preparation for a final inspection before final air clearance monitoring. The Contractor and the CO shall conduct a final visual inspection of the cleaned regulated area in accordance with ASTM E 1368 and document the results . If the CO rejects the clean regulated area as not meeting final cleaning requirements, reclean as necessary and have a follow-on inspection conducted with the CO. Recleaning and follow-up reinspection shall be at the Contractor's expense.

3.8 LOCKDOWN

Prior to removal of plastic barriers and after final visual inspection, a (lockdown) encapsulant shall be spray applied to ceiling, walls, floors, and other surfaces in the regulated area.

3.9 EXPOSURE ASSESSMENT AND AIR MONITORING

3.9.1 General Requirements

a. Exposure assessment, air monitoring and analysis of airborne concentration of asbestos fibers shall be performed in accordance with 29 CFR 1926.1101, and the Contractor's air monitoring plan. Results of breathing zone samples shall be posted at the job site and made available to the CO. Submit all documentation regarding initial exposure assessments, negative exposure assessments, and air-monitoring results.

b. Worker Exposure.

(1) The Contractor's Designated IH shall collect samples representative of the exposure of each employee who is assigned to work within a regulated area. Breathing zone samples shall be taken for at least 25 percent of the workers in each shift, or a minimum of 2, whichever is greater. Air monitoring results at the 95 percent confidence level shall be calculated as shown in Table 2 at the end of this section.

(2) Workers shall not be exposed to an airborne fiber concentration in excess of 1.0 f/cc, as averaged over a sampling period of 30 minutes. Should a personal excursion concentration of 1.0 f/cc expressed as a 30-minute sample occur inside a regulated work area, stop work immediately, notify the Contracting Officer, and implement additional engineering controls and work practice controls to reduce airborne fiber levels below prescribed limits in the work area. Do not restart work until authorized by the CO.

c. Environmental Exposure

(1) All environmental air monitoring shall be performed by the Contractor's Designated IH.

(2) Environmental and final clearance air monitoring shall be performed using NIOSH 94-113 Method 7400 (PCM) with optional confirmation of results by OSHA or EPA TEM.

(3) For environmental and final clearance, air monitoring shall be conducted at a sufficient velocity and duration to establish the limit of detection of the method used at 0.005 f/cc.

(4) When confirming asbestos fiber concentrations (asbestos f/cc) from environmental and final clearance samples, use TEM in accordance with NIOSH 94-113 Method 7402. When such confirmation is conducted, it shall be from the same sample filter used for the NIOSH 94-113 Method 7400 PCM analysis. All confirmation of asbestos fiber concentrations, using NIOSH 94-113 Method 7402, shall be at the Contractor's expense.

(5) Monitoring may be duplicated by the Government at the discretion of the CO and at the Government's expense.

(6) Maintain a fiber concentration inside a regulated area less than or equal to 0.1 f/cc expressed as an 8 hour, time-weighted

average (TWA) during the conduct of the asbestos abatement.

(7) At the discretion of the Contracting Officer, fiber concentration may exceed 0.1 f/cc but shall not exceed 1.0 f/cc expressed as an 8-hour TWA. Should an environmental concentration of 1.0 f/cc expressed as an 8-hour TWA occur inside a regulated work area, stop work immediately, notify the Contracting Officer, and implement additional engineering controls and work practice controls to reduce airborne fiber levels below prescribed limits in the work area. Work shall not restart until authorized by the CO.

3.9.2 Initial Exposure Assessment

The Contractor's Designated IH shall conduct an exposure assessment immediately before or at the initiation of an asbestos abatement operation to ascertain expected exposures during that operation. The assessment shall be completed in time to comply with the requirements, which are triggered by exposure data or the lack of a negative exposure assessment, and to provide information necessary to assure that all control systems planned are appropriate for that operation. The assessment shall take into consideration both the monitoring results and all observations, information or calculations which indicate employee exposure to asbestos, including any previous monitoring conducted in the workplace, or of the operations of the Contractor which indicate the levels of airborne asbestos likely to be encountered on the job. For Class I asbestos work, until the employer conducts exposure monitoring and documents that employees on that job will not be exposed in excess of PEL, or otherwise makes a negative exposure assessment, presume that employees are exposed in excess of the PEL-TWA and PEL-Excursion Limit.

3.9.3 Negative Exposure Assessment

Provide a negative exposure assessment for the specific asbestos job which will be performed and conform to the following criteria:

a. Objective Data: Objective data demonstrating that the product or material containing asbestos minerals or the activity involving such product or material cannot release airborne fibers in concentrations exceeding the PEL-TWA and PEL-Excursion Limit under those work conditions having the greatest potential for releasing asbestos.

b. Prior Asbestos Jobs: Where the Contractor has monitored prior asbestos jobs for the PEL and the PEL-Excursion Limit within 12 months of the current job, the monitoring and analysis were performed in compliance with asbestos standard in effect; the data were obtained during work operations conducted under workplace conditions closely resembling the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the Contractor's current operations; the operations were conducted by employees whose training and experience are no more extensive than that of employees performing the current job; and these data show that under the conditions prevailing and which will prevail in the current workplace, there is a high degree of certainty that the monitoring covered exposure from employee exposures will not exceed the PEL-TWA and PEL-Excursion Limit.

c. Initial Exposure Monitoring: The results of initial exposure monitoring of the current job, made from breathing zone air samples that are representative of the 8-hour PEL-TWA and 30-minute short-term exposures of each employee. The monitoring covered exposure from operations which are most likely during the performance of the entire asbestos job to result in exposures over the PEL.

3.9.4 Preabatement Environmental Air Monitoring

Preabatement environmental air monitoring shall be established 1 day prior to the masking and sealing operations for each regulated area to determine background concentrations before abatement work begins. As a minimum, preabatement air samples shall be collected using NIOSH 94-113 Method 7400, PCM at these locations: outside the building; inside the building, but outside the regulated area perimeter; and inside each regulated work area. One sample shall be collected for every 185 square meters (2000 square feet) of floor space. At least 2 samples shall be collected outside the building: at the exhaust of the HEPA unit; and downwind from the abatement site. The PCM samples shall be analyzed within 24 hours; and if any result in fiber concentration greater than 0.01 f/cc, asbestos fiber concentration shall be confirmed using NIOSH 94-113 Method 7402 (TEM).

3.9.5 Environmental Air Monitoring During Abatement

Until an exposure assessment is provided to the CO, environmental air monitoring shall be conducted at locations and frequencies that will accurately characterize any evolving airborne asbestos fiber concentrations. The assessment shall demonstrate that the product or material containing asbestos minerals, or the abatement involving such product or material, cannot release airborne asbestos fibers in concentrations exceeding 0.01 f/cc as a TWA under those work conditions having the greatest potential for releasing asbestos. The monitoring shall be at least once per shift at locations including, but not limited to, close to the work inside a regulated area; preabatement sampling locations; outside entrances to a regulated area; close to glove bag operations; representative locations outside of the perimeter of a regulated area; inside clean room; and at the exhaust discharge point of local exhaust system ducted to the outside of a containment (if used). If the sampling outside regulated area shows airborne fiber levels have exceeded background or 0.01 f/cc, whichever is greater, work shall be stopped immediately, and the Contracting Officer notified. The condition causing the increase shall be corrected. Work shall not restart until authorized by the CO.

3.9.6 Final Clearance Air Monitoring

The Contractor's Designated IH shall conduct final clearance air monitoring using aggressive air sampling techniques as defined in 40 CFR 763, Subpart E, Appendix A, Unit III, TEM Method B.7(d-f) and Table 4 of this section for all indoor asbestos abatement projects. Clearance air monitoring is not required for outside work or for soil cleanups.

3.9.6.1 Final Clearance Requirements, NIOSH PCM Method

For PCM sampling and analysis using NIOSH 94-113 Method 7400, the fiber concentration inside the abated regulated area, for each airborne sample, shall be less than 0.01 f/cc. The abatement inside the regulated area is considered complete when every PCM final clearance sample is below the clearance limit. If any sample result is greater than 0.01 total f/cc, the asbestos fiber concentration (asbestos f/cc) shall be confirmed from that same filter using NIOSH 94-113 Method 7402 (TEM) at Contractor's expense. If any confirmation sample result is greater than 0.01 asbestos f/cc, abatement is incomplete and cleaning shall be repeated. Upon completion of any required recleaning, resampling with results to meet the above clearance criteria shall be done.

3.9.6.2 Final Clearance Requirements, EPA TEM Method

For EPA TEM sampling and analysis, using the EPA Method specified in 40 CFR 763, abatement inside the regulated area is considered complete when the arithmetic mean asbestos concentration of the 5 inside samples is less than or equal to 70 structures per square millimeter (70 S/mm). When the arithmetic mean is greater than 70 S/mm, the 3 blank samples shall be analyzed. If the 3 blank samples are greater than 70 S/mm, resampling shall be done. If less than 70 S/mm, the 5 outside samples shall be analyzed and a Z-test analysis performed. When the Z-test results are less than 1.65, the decontamination shall be considered complete. If the Z-test results are more than 1.65, the abatement is incomplete and cleaning shall be repeated. Upon completion of any required recleaning, resampling with results to meet the above clearance criteria shall be done.

3.9.6.3 Air Clearance Failure

If clearance sampling results fail to meet the final clearance requirements, pay all costs associated with the required recleaning, resampling, and analysis, until final clearance requirements are met.

3.9.7 Air-Monitoring Results and Documentation

Air sample fiber counting shall be completed and results provided within 24 hours (breathing zone samples. The CO shall be notified immediately of any airborne levels of asbestos fibers in excess of established requirements. Written sampling results shall be provided within 5 working days of the date of collection. The written results shall be signed by testing laboratory analyst, testing laboratory principal and the Contractor 's Designated IH. The air sampling results shall be documented on a Contractor's daily air monitoring log. The daily air monitoring log shall contain the following information for each sample:

a. Sampling and analytical method used;

b. Date sample collected;

c. Sample number;

d. Sample type: BZ = Breathing Zone (Personal), P = Preabatement, E = Environmental, C = Abatement Clearance;

e. Location/activity/name where sample collected;

f. Sampling pump manufacturer, model and serial number, beginning flow rate, end flow rate, average flow rate (L/min);

g. Calibration date, time, method, location, name of calibrator, signature;

h. Sample period (start time, stop time, elapsed time (minutes);

i. Total air volume sampled (liters);

j. Sample results (f/cc and S/mm square) if EPA methods are required for final clearance;

k. Laboratory name, location, analytical method, analyst, confidence level. In addition, the printed name and a signature and date block for the Industrial Hygienist who conducted the sampling and for the Industrial Hygienist who reviewed the daily air monitoring log verifying the accuracy of the information.

3.10 CLEARANCE CERTIFICATION

When asbestos abatement is complete, ACM waste is removed from the regulated areas, and final clean-up is completed, the CO will allow the warning signs and boundary warning tape to be removed. After final clean-up and acceptable airborne concentrations are attained, but before the HEPA unit is turned off and the containment removed, the Contractor shall remove all pre-filters on the building HVAC system and provide new pre-filters. Dispose of such filters as asbestos contaminated materials. HVAC, mechanical, and electrical systems shall be re-established in proper working order. The Contractor and the CO shall visually inspect all surfaces within the containment for residual material or accumulated debris. Reclean all areas showing dust or residual materials. The CO will certify in writing that the area is safe before unrestricted entry is permitted. The Government will have the option to perform monitoring to certify the areas are safe before entry is permitted.

3.11 CLEANUP AND DISPOSAL

3.11.1 Title to ACM Materials

ACM material resulting from abatement work, except as specified otherwise, shall become the property of the Contractor and shall be disposed of as specified and in accordance with applicable local regulations.

3.11.2 Collection and Disposal of Asbestos

All ACM waste shall be collected including contaminated wastewater filters, scrap, debris, bags, containers, equipment, and asbestos contaminated clothing and placed in leak-tight containers. Waste within the containers shall be wetted in case the container is breeched. Asbestos-containing waste shall be disposed of off Government property. For temporary storage, sealed impermeable containers shall be stored in an asbestos waste load-out unit or in a storage/transportation conveyance (i.e., dumpster, roll-off waste boxes, etc.) in a manner acceptable to and in an area assigned by the CO. Procedure for hauling and disposal shall comply with 40 CFR 61, Subpart M, local standards. Submit manufacturer's catalog data for all materials and equipment to be used, including brand name, model, capacity, performance characteristics and any other pertinent information. Test results and certificates from the manufacturer of encapsulants substantiating compliance with performance requirements of this specification. Material Safety Data Sheets for all chemicals to be used onsite in the same format as implemented in the Contractor's HAZARD COMMUNICATION PROGRAM. Data shall include, but shall not be limited to, the following items:

a. High Efficiency Filtered Air (HEPA) local exhaust equipment

b. Vacuum cleaning equipment

c. Pressure differential monitor for HEPA local exhaust equipment

d. Air monitoring equipment

e. Respirators

f. Personal protective clothing and equipment

g. Glove bags. Written manufacturer's proof that glove bags will not break down under expected temperatures and conditions.

h. Duct Tape

i. Disposal Containers

j. Sheet Plastic

k. Wetting Agent

l. Strippable Coating

m. Prefabricated Decontamination Unit

n. Material Safety Data Sheets (for all chemicals proposed)

3.11.3 Records and Management Plan

3.11.3.1 Asbestos Waste Shipment Records

Complete and provide the CO final completed copies of the Waste Shipment Record for all shipments of waste material as specified in 40 CFR 61, Subpart M and other required waste manifest shipment records, within 3 days of delivery to the landfill. Each Waste Shipment Record shall be signed and dated by the Contractor, the waste transporter and disposal facility operator.

3.11.3.2 Asbestos Management Plan

Provide a summary, in electronic form, of site activities (bulk samples, asbestos removed, repaired, encased, etc.) for updating the installation Asbestos Management Plan.

TABLE 2

FORMULA FOR CALCULATION OF THE 95 PERCENT CONFIDENCE LEVEL
(Reference: NIOSH 7400)

Fibers/cc(01.95 percent CL) = X + (X) * (1.645) * (CV)

Where: X = ((E)(AC))/((V)(1000))

E = ((F/Nf) - (B/Nb))/Af

CV = The precision value; 0.45 shall be used unless the analytical laboratory provides the Contracting Officer with documentation (Round Robin Program participation and results) that the laboratory's precision is better.

AC = Effective collection area of the filter in square millimeters

V = Air volume sampled in liters

E = Fiber density on the filter in fibers per square millimeter

F/Nf = Total fiber count per graticule field

B/Nb = Mean field blank count per graticule field

Af = Graticule field area in square millimeters

TWA = C1/T1 + C2/T2 = Cn/Tn

Where: C = Concentration of contaminant

T = Time sampled.

TABLE 3

NIOSH METHOD 7400

PCM ENVIRONMENTAL AIR SAMPLING PROTOCOL (NON-PERSONAL)

Sample Location	Minimum No. of Samples	Filter Pore Size (Note 1)	Min. Vol. (Note 2) (Liters)	Sampling Rate (liters/min.)
Inside Abatement Area	0.5/140 Square Meters (Notes 3 & 4)	0.45 microns	3850	2-16
Each Room in 1 Abatement Area Less than 140 Square meters		0.45 microns	3850	2-16
Field Blank	2	0.45 microns	0	0
Laboratory Blank	1	0.45 microns	0	0

Notes:

1. Type of filter is Mixed Cellulose Ester.

2. Ensure detection limit for PCM analysis is established at 0.005 fibers/cc.

3. One sample shall be added for each additional 140 square meters. (The corresponding I-P units are 5/1500 square feet).

4. A minimum of 5 samples are to be taken per abatement area, plus 2 field blanks.

TABLE 4

EPA AHERA METHOD: TEM AIR SAMPLING PROTOCOL

Location Sampled	Minimum No. of Samples	Filter Pore Size	Min. Vol. (Liters)	Sampling Rate (liters/min.)
Inside Abatement Area	5	0.45 microns	1500	2-16
Outside Abatement Area	5	0.45 microns	1500	2-16
Field Blank	2	0.45 microns	0	0
Laboratory Blank	1	0.45 microns	0	0

Notes:

1. Type of filter is Mixed Cellulose Ester.

2. The detection limit for TEM analysis is 70 structures/square mm.

CERTIFICATE OF WORKER'S ACKNOWLEDGMENT

PROJECT NAME _________________________ CONTRACT NO. ______________________
PROJECT ADDRESS ____
CONTRACTOR FIRM NAME ____
EMPLOYEE'S NAME _________________________,_______________,______,
(Print) (Last) (First) (MI)

Social Security Number: _______-_______-________, __(Optional)

WORKING WITH ASBESTOS CAN BE DANGEROUS. INHALING ASBESTOS FIBERS HAS BEEN LINKED WITH TYPES OF LUNG DISEASE AND CANCER. IF YOU SMOKE AND INHALE ASBESTOS FIBERS, THE CHANCE THAT YOU WILL DEVELOP LUNG CANCER IS GREATER THAN THAT OF THE NONSMOKING PUBLIC.

Your employer's contract for the above project requires that you be provided and you complete formal asbestos training specific to the type of work you will perform and project specific training; that you be supplied with proper personal protective equipment including a respirator, that you be trained in its use; and that you receive a medical examination to evaluate your physical capacity to perform your assigned work tasks, under the environmental conditions expected, while wearing the required personal protective equipment. These things are to be done at no cost to you. By signing this certification, you are acknowledging that your employer has met these obligations to you. The Contractor's Designated Industrial Hygienist will check the block(s) for the type of formal training you have completed. Review the checked blocks prior to signing this certification.

FORMAL TRAINING:
_____ a. For Competent Persons and Supervisors: I have completed EPA's Model Accreditation Program (MAP) training course, "Contractor/Supervisor", that meets this State's requirements.

b. For Workers:
_____ (1) For OSHA Class I work: I have completed EPA's MAP training course, "Worker", which meets local requirements.
_____ (2) For OSHA Class II work (where there will be abatement of more than one type of Class II materials, i.e., roofing, siding, floor tile, etc.): I have completed EPA's MAP training course, "Worker", which meets local requirements.
(3) For OSHA Class II work (there will only be abatement of one type of Class II material):
_____ (a) I have completed an 8-hour training class on the elements of 29 CFR 1926.1101(k)(9)(viii), in addition to the specific work practices and engineering controls of 29 CFR 1926.1101(g) and hands-on training.
_____ (b) I have completed EPA's MAP training course, "Worker", that meets USFK Reg 201-1.
_____ (4) For OSHA Class III work: I have completed at least a 16-hour course consistent with EPA requirements for training of local education agency maintenance and custodial staff at 40 CFR 763, Section .92(a)(2) and the elements of 29 CFR 1926.1101(k)(9)(viii), in addition to the specific work practices and engineering controls at 29 CFR 1926.1101, and hands-on training.

CERTIFICATE OF WORKER'S ACKNOWLEDGMENT

_____ (5) For OSHA Class IV work: I have completed at least a 2-hr course consistent with EPA requirements for training of local education agency maintenance and custodial staff at 40 CFR 763, (a)(1), and the elements of 29 CFR 1926.1101(k)(9)(viii), in addition to the specific work practices and engineering controls at 29 CFR 1926.1101(g) and hands-on training.

_____ c. Workers, Supervisors and the Designated Competent Person: I have completed annual refresher training as required by EPA's MAP that meets this State's requirements.

PROJECT SPECIFIC TRAINING:
_____ I have been provided and have completed the project specific training required by this Contract. My employer's Designated Industrial Hygienist and Designated Competent Person conducted the training.

RESPIRATORY PROTECTION:
_____ I have been trained in accordance with the criteria in the Contractor's Respiratory Protection program. I have been trained in the dangers of handling and breathing asbestos dust and in the proper work procedures and use and limitations of the respirator(s) I will wear. I have been trained in and will abide by the facial hair and contact lens use policy of my employer.

RESPIRATOR FIT-TEST TRAINING:
_____ I have been trained in the proper selection, fit, use, care, cleaning, maintenance, and storage of the respirator(s) that I will wear. I have been fit-tested in accordance with the criteria in the Contractor's Respiratory Program and have received a satisfactory fit. I have been assigned my individual respirator. I have been taught how to properly perform positive and negative pressure fit-check upon donning negative pressure respirators each time.

EPA CERTIFICATION/LICENSE

I have an EPA certification/license as:
Building Inspector/Management Planner; Certification #______
Contractor/Supervisor, Certification # _____________________
Project Designer, Certification # __________________________
Worker, Certification # ____________________________________

MEDICAL EXAMINATION:
_____ I have had a medical examination within the last twelve months which was paid for by my employer. The examination included: health history, pulmonary function tests, and may have included an evaluation of a chest x-ray. A physician made a determination regarding my physical capacity to perform work tasks on the project while wearing personal protective equipment including a respirator. I was personally provided a copy and informed of the results of that examination. My employer's Industrial Hygienist evaluated the medical certification provided by the physician and checked the appropriate blank below. The physician determined that there:

_____ were no limitations to performing the required work tasks.
_____ were identified physical limitations to performing the required work tasks.

CERTIFICATE OF WORKER'S ACKNOWLEDGMENT

Date of the medical examination __________________

Employee Signature ______________________________________ date ___________

Contractor's Industrial
Hygienist Signature _____________________________________ date ___________

-- End of Section --

SECTION 02 83 19.00 10

LEAD BASED PAINT HAZARD ABATEMENT, TARGET HOUSING & CHILD OCCUPIED FACILITIES
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA)

AIHA Z9.2	(2006) Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems

ASTM INTERNATIONAL (ASTM)

ASTM E1613	(2004) Determination of Lead by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Flame Atomic Absorption Spectrometry (FAAS), or Graphite Furnace Atomic Absorption Spectometry (GFAAS) Techniques
ASTM E1644	(2004e1; R 2012) Hot Plate Digestion of Dust Wipe Samples for the Determination of Lead
ASTM E1726	(2001; R 2009) Preparation of Soil Samples by Hotplate Digestion for Subsequent Lead Analysis
ASTM E1727	(2005) Field Collection of Soil Samples for Lead Determination by Atomic Spectrometry Techniques

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 701	(2010) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

HUD 6780	(1995; Errata Aug 1996;Rev Ch. 7 - 1997) Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 745	Lead-Based Paint Poisoning Prevention in Certain Residential Structures

UNDERWRITERS LABORATORIES (UL)

UL 586	(2009; Reprint Sep 2014) Standard for High-Efficiency Particulate, Air Filter Units

REPUBLIC OF KOREA (ROK) LAW

Act No. 10389	(23 JUL 2010) Korean Waste Management Act (WMA)
PD No. 22631	(21 JAN 2011) Korean Presidential Decree (PD) of WMA
MD No. 406	(31 MAR 2011) Korean Ministry of Environment, Ministerial Decree (MD) of WMA

1.2 DEFINITIONS

1.2.1 Abatement

Measures defined in 40 CFR 745, Section 223, designed to permanently eliminate lead-based paint hazards.

1.2.2 Target Housing

Residential real property which is housing constructed prior to 1978, except housing for the elderly or persons with disabilities (unless any one or more children age 6 years or under resides or is expected to reside in such housing for the elderly or persons with disabilities) or any 0 bedroom dwelling.

1.2.3 Child-Occupied Facility

Real property which is a building or portion of a building constructed prior to 1978 visited regularly by the same child, 6 years of age or under, on at least two different days, provided that each day's visit lasts at least 6 hours, and the combined annual visits last at least 60 hours. Child-occupied facilities include but are not limited to, day-care centers, preschools and kindergarten classrooms.

1.2.4 Lead-Based Paint Hazards

Paint-lead hazard, dust-lead hazard or soil-lead hazard as identified in 40 CFR 745, Section 65.

1.3 SYSTEM DESCRIPTION

The work covered by this section includes work tasks, on the individual work task data sheets at the end of this section, and the precautions specified in this section for the protection of building occupants and the environment during and after the performance of lead hazard abatement activities.

1.3.1 Protection of Existing Areas to Remain

All project work including, but not limited to, lead hazard abatement work, storage, transportation, and disposal shall be performed without damaging or contaminating adjacent work and areas. Where such work or areas are damaged or contaminated, restore work and areas to the original condition.

1.3.2 Coordination with Other Work

Coordinate lead hazard abatement activities with work being performed in adjacent areas. Coordination procedures shall be explained in the Contractor's Accident Prevention Plan and describe how the Contractor will prevent lead exposure to other Contractors and/or Government personnel performing work unrelated to lead hazard abatement activities.

1.3.3 Sampling and Analysis

Submit a log of the analytical results from sampling conducted during the abatement. The log of results shall be kept current with project activities and shall be briefed to the Contracting Officer as analytical results are reported.

1.3.3.1 Dust Wipe Materials, Sampling and Analysis

Sampling shall conform to ASTM E1728 or ASTM E1792, as applicable. Analysis shall conform to ASTM E1613 and ASTM E1644.

1.3.3.2 Soil Sampling and Analysis

Sampling shall conform to ASTM E1727. Analysis shall conform to ASTM E1613 and ASTM E1726.

1.3.3.3 Clearance Monitoring

a. Take dust wipe samples inside the lead hazard control area after the final visual inspection in the quantities and at the locations specified.

    (1) Floors .
    (2) Interior Window Sills .
    (3) Window Troughs .

b. Take exterior bare soil samples inside the lead hazard control area after the final visual inspection in the quantities and at the locations specified.

    (1) Near the building foundation .
    (2) Nearby Play areas .

1.3.4 Clearance Requirements

Target housing and child occupied facilities clearance levels.

(1) Floors .
(2) Interior Window Sills .
(3) Window Troughs .
(4) Bare soils in play areas accessible by children .
(5) Bare soils in all other areas .

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When

used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Materials and Equipment
Expendable Supplies
Qualifications; G
Occupant Protection Plan; G

SD-06 Test Reports

Pressure Differential Log
Licenses, Permits and Notifications; G
Sampling and Analysis
Abatement Report; G

1.5 QUALITY ASSURANCE

1.5.1 Qualifications and Organization Report

Submit a qualification and organization report. The report shall describe the qualifications of the certified supervisor, certified risk assessor, and certified abatement workers. Include in the report an organization chart showing the Contractor's personnel by name and title and project specific responsibilities and authorities. The report shall describe the qualifications of the laboratories selected for this project. The report shall be signed by the Contractor and the certified abatement supervisor to indicate that all personnel and laboratories comply with certification and experience requirements of this section and that project personnel have been given the authority to complete the tasks assigned to them.

1.5.2 Personnel and Subcontractor Responsibilities and Qualifications

1.5.2.1 Certified Abatement Supervisor

The abatement supervisor shall be certified pursuant to 40 CFR 745, Section 226 and is responsible for development and implementation of the occupant protection plan, the abatement report and shall supervise lead hazard abatement work activities.

1.5.2.2 Lead Hazard Abatement Workers

Lead hazard abatement workers shall be certified pursuant to 40 CFR 745, Section 226 and shall be responsible for performing the labor necessary to complete the lead hazard abatement activities required in this contract.

1.5.2.3 Certified Risk Assessor

The Certified Risk Assessor shall be certified pursuant to 40 CFR 745, Section 226 and shall be responsible to perform the clearance sampling, clearance sample data evaluation and shall summarize clearance sampling results in a section of the abatement report. The risk assessor shall sign the abatement report to indicate clearance requirements for the contract have been met.

1.5.2.4 Testing Laboratories

The laboratory selected to perform analysis on dust wipe, paint chip and soil samples shall be recognized by the EPA's National Lead Laboratory Accreditation Program (NLLAP).

1.5.3 Regulatory Requirements

Applicable ROK national, provincial, and local statutes, regulations and requirements shall apply to lead hazard control activities to be performed, including, but not necessarily limited to Act No. 10389, MD No. 406, and PD No. 22631.

1.5.4 Occupant Protection Plan

The certified supervisor shall develop and implement an Occupant Protection Plan describing the measures and management procedures to be taken during lead hazard abatement activities to protect the building occupants/building facilities and the outside environment from exposure to any lead contamination while lead hazard abatement activities are performed.

1.5.5 Licenses, Permits and Notifications

Certify and submit in writing to the Contracting Officer at least 10 days prior to the commencement of work that licenses, permits and notifications have been obtained. The Contractor is responsible for all associated fees or costs incurred in obtaining the licenses, permits and notifications.

1.5.6 Training

Provide training to meet 40 CFR 745 Subpart L requirements by an EPA accredited training provider; provide proof in the Qualifications and Organization Report showing that personnel have passed certification examinations for their respective disciplines, that fees for certification have been paid to the EPA and that EPA has certified the supervisor, risk assessor, workers to perform their duties.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment needed to complete the project, shall be available and kept on the site. Submit a description of the materials and equipment required; including Material Safety Data Sheets (MSDSs) for material brought onsite to perform the work.

2.1.1 Expendable Supplies

Submit a description of the expendable supplies required.

2.1.1.1 Polyethylene Bags

Disposable bags shall be polyethylene plastic and shall be a minimum of 0.15 mm (6 mils) thick (0.1 mm (4 mils) thick if double bags are used) or any other thick plastic material shown to demonstrate at least equivalent performance; and shall be capable of being made leak-tight. Leak-tight means that solids, liquids or dust cannot escape or spill out.

2.1.1.2 Polyethylene Leak-tight Wrapping

Wrapping used to wrap lead contaminated debris shall be polyethylene plastic that is a minimum of 0.15 mm (6 mils) thick or any other thick plastic material shown to demonstrate at least equivalent performance.

2.1.1.3 Polyethylene Sheeting

Sheeting shall be polyethylene plastic with a minimum thickness of 0.15 mm (6 mil), or any other thick plastic material shown to demonstrate at least equivalent performance; and shall be provided in the largest sheet size reasonably accommodated by the project to minimize the number of seams. Where the project location constitutes an out of the ordinary potential for fire, or where unusual fire hazards cannot be eliminated, flame-resistant polyethylene sheets which conform to the requirements of NFPA 701 shall be provided.

2.1.1.4 Tape and Adhesive Spray

Tape and adhesive shall be capable of sealing joints between polyethylene sheets and for attachment of polyethylene sheets to adjacent surfaces. After dry application, tape or adhesive shall retain adhesion when exposed to wet conditions, including amended water. Tape shall be minimum 50 mm (2 inches) wide, industrial strength.

2.1.1.5 Containers

When used, containers shall be leak-tight and shall be labeled in accordance with EPA, OSHA, and ROK national, provincial, and local standards.

2.1.1.6 Chemical Paint Strippers

Chemical paint strippers shall not contain methylene chloride and shall be formulated to prevent stain, discoloration, or raising of the substrate materials.

2.1.1.7 Chemical Paint Stripper Neutralizer

Neutralizers for paint strippers shall be compatible with the substrate and suitable for use with the chemical stripper that has been applied to the surface.

2.1.1.8 Detergents and Cleaners

Detergents or cleaning agents shall not contain trisodium phosphate and shall have demonstrated effectiveness in lead control work using cleaning techniques specified by HUD 6780 guidelines.

2.2 EQUIPMENT

2.2.1 Abrasive Removal Equipment

The use of powered machine for vibrating, sanding, grinding, or abrasive blasting is prohibited unless equipped with local exhaust ventilation systems equipped with high efficiency particulate air (HEPA) filters.

2.2.2 Negative Air Pressure System

2.2.2.1 Minimum Requirements

Work shall not proceed in the area until containment is set up and HEPA filtration systems are in place. The negative air pressure system shall meet the requirements of AIHA Z9.2 including approved HEPA filters in accordance with UL 586. Negative air pressure equipment shall be equipped with new HEPA filters, and shall be sufficient to maintain a minimum pressure differential of minus 0.005 kPa (0.02 inch of water column) relative to adjacent, unsealed areas. Negative air pressure system minimum requirements are listed as follows:

a. The unit shall be capable of delivering its rated volume of air with a clean first stage filter, an intermediate filter and a primary HEPA filter in place.

b. The HEPA filter shall be certified as being capable of trapping and retaining mono-dispersed particles as small as 0.3 micrometers at a minimum efficiency of 99.97 percent.

c. The unit shall be capable of continuing to deliver no less than 70 percent of rated capacity when the HEPA filter is 70 percent full or measures 0.625 kPa (2.5 inches of water) static pressure differential on a magnehelic gauge.

d. The unit shall be equipped with a manometer-type negative pressure differential monitor with minor scale division of 0.005 kPa (0.02 inch of water) and accuracy within plus or minus 1.0 percent. The manometer shall be calibrated daily as recommended by the manufacturer.

e. The unit shall be equipped with a means for the operator to easily interpret the readings in terms of the volumetric flow rate of air per minute moving through the machine at any given moment.

f. The unit shall be equipped with an electronic mechanism that automatically shuts the machine off in the event of a filter breach or absence of a filter.

g. The unit shall be equipped with an audible horn that sounds an alarm when the machine has shut itself off.

h. The unit shall be equipped with an automatic safety mechanism that prevents a worker from improperly inserting the main HEPA filter.

2.2.2.2 Auxiliary Generator

Provide an auxiliary generator with capacity to power a minimum of 50 percent of the negative air machines at any time during the work. When power fails, the generator controls shall automatically start the generator and switch the negative air pressure system machines to generator power. The generator shall not present a carbon monoxide hazard to workers.

2.2.3 Vacuum Systems

Vacuum systems shall be suitably sized for the project, and filters shall be capable of trapping and retaining all mono-disperse particles as small as 0.3 micrometers (mean aerodynamic diameter) at a minimum efficiency of

99.97 percent. Used filters that are being replaced shall be disposed in a proper manner.

2.2.4 Heat Blower Guns

Heat blower guns shall be flameless, electrical, paint-softener type with controls to limit temperature to 590 degrees C (1,100 degrees F). Heat blower shall be DI (non-grounded) 120 volts ac, and shall be equipped with cone, fan, glass protector and spoon reflector nozzles.

PART 3 EXECUTION

3.1 WORK PROCEDURES

Perform work following practices and procedures in project work plans and the occupant protection plan.

3.1.1 Lead Hazard Control Areas, Equipment and Procedures

Set up lead hazard control areas and operate equipment within the lead hazard control area in a manner that will minimize migration of lead dust beyond the lead hazard control area boundaries.

3.1.2 Lead Hazard Control Areas

Access into lead hazard control areas by the general public shall be prohibited. Lead hazard control area preparation and restriction requirements follow:

a. Containment features for interior lead hazard control projects: Polyethylene sheeting sealed with spray adhesive and duct tape to designate the lead hazard control area. The floor in the lead hazard control area shall be covered with two layers of polyethylene sheeting. The entry/exit shall be sealed with a primitive air lock Openings, such as HVAC supply and return air vents, into the lead hazard control area shall be sealed with polyethylene sheeting and duct tape or with sealed rigid coverings.

b. Containment features for exterior lead hazard control projects: A roped-off boundary perimeter, using caution tape or a barrier installed at distance indicated in contract drawings from where the lead control work is performed.

3.1.3 Negative Air Pressure System Containment

a. The negative air pressure systems shall be operated to provide at least 10 air changes per hour inside the containment. The local exhaust unit equipment shall be operated continuously until the containment is removed. The negative air pressure system shall be smoke tested for leaks at the beginning of each shift. The certified supervisor is responsible to continuously monitor and keep a pressure differential log with an automatic manometric recording instrument. The Contracting Officer shall be notified immediately if the pressure differential falls below the prescribed minimum. Submit the continuously monitored pressure differential log, as specified. The building ventilation system shall not be used as the local exhaust system. The local exhaust system shall terminate out of doors unless the Contracting Officer allows an alternate arrangement. All filters shall be new at the beginning of the project and shall be periodically changed as necessary to maintain specified pressure differential and shall be disposed of as lead contaminated waste.

b. Discontinuing Negative Air Pressure System. The negative air pressure system shall be operated continuously during abatement activities unless otherwise authorized by the Contracting Officer. At the completion of the project, units shall be run until full cleanup has been completed and final clearance testing requirements have been met. Dismantling of the negative air pressure systems shall be as presented in the Lead Hazard Control Plan. The HEPA filter machine intakes shall be sealed with polyethylene to prevent environmental contamination.

3.2 FURNISHINGS

Remove furniture and equipment from the work area before lead hazard control work begins.

3.3 LEAD-BASED PAINT ABATEMENT METHODS AND TECHNIQUES

Lead based paint abatement techniques for building components and landscape features are specified on the individual work task data element sheets at the end of this section.

3.4 CLEARANCE PROCEDURES

3.4.1 Visual Inspection

The certified supervisor shall perform a visual inspection, using the form at the end of this section, to assure that lead hazard abatement activities, identified in the individual work task data elements, have been properly completed. The certified supervisor shall visually verify that lead hazards have been abated and the area is free of dust and paint chips generated by lead hazard abatement activities.

3.4.2 Analytical Demonstration of Clearance

After the visual inspection, the certified risk assessor shall take clearance samples for laboratory analysis to verify clearance requirements specified in paragraph CLEARANCE REQUIREMENTS in PART 1 have been met.

3.4.3 Clearance

The certified risk assessor shall review analytical results for the samples taken to determine compliance with project specific clearance requirements. The following actions apply and shall be performed at the Contractor's expense if project specific clearance levels are exceeded:

Reclean surfaces.
Retest to determine clearance.

3.5 ABATEMENT REPORT

Submit the report, written by the certified supervisor, covering each element in 40 CFR 745, Section 227 (e) (10). The following information shall be covered in the abatement report:

a. Start and completion dates of lead hazard control activities.

b. The name and address of each firm conducting lead hazard control activities and the name of each supervisor assigned to the project.

c. The Occupant Protection Plan prepared pursuant to paragraph OCCUPANT PROTECTION PLAN in PART 1.

d. The name, address and signature of the certified risk assessor to indicating clearance requirements have been met.

e. Certification of each Final Cleaning and Visual Inspection performed by the certified supervisor.

f. The results of clearance testing and all soil analyses, and the name of each laboratory that conducted the analyses.

g. A detailed written description of the lead abatement including abatement methods used, locations of rooms and/or components where lead abatement activities occurred, reason for selecting particular abatement methods for each component, and any suggested monitoring of encapsulants or enclosures.

h. Hazardous waste disposal documentation.

i. Contractor provided installation/maintenance manuals.

3.6 CERTIFICATION OF VISUAL INSPECTION

Certify that the lead hazard control area(s) for each individual work task data elements have passed visual clearance criteria and are ready for clearance sampling. To pass visual clearance, lead hazards have to be removed; control technology appropriately applied/installed; the lead hazard control area must be free from visible dust debris, paint chips or any other residue that may have been generated by the lead hazard control activities.

Signature by the certified supervisor indicates that the described lead hazard control area(s) have passed visual clearance criteria. Provide detailed description of each Lead Hazard Control Area.

____

____

____

BY:____
Certified Supervisor Date

Print name and title ____

CONTRACTING OFFICER ACCEPTANCE OR REJECTION

The Contracting Officer hereby determines that the Contractor has performed visual inspection of the lead hazard control area and by quality assurance inspection, finds the Contractor's work to be:

________ Acceptable, ready for performance of clearance sampling

________ Unacceptable, Contractor instructed to re-clean the lead hazard control area

BY: Contracting Officer's Representative

____
Signature Date

Print name and title____

Lead Hazard Control Clearance Sampling Certification Form

Date_____

Name of Certified Risk
Assessor____

License No.____

Work Task Data Element ________

Sample quantity and location:
Windows _____________
Floors ______________
Exterior Soils ______

Date of sample collection_______________Date Shipped to lab________________

Shipped by____
Signature

I certify that the clearance samples taken meet the clearance sampling requirements of this contract.

By:____________________ Date:___________________
Certified Risk Assessor

Print name and Title:____

CONTRACTING OFFICER ACCEPTANCE OR REJECTION

I have inspected sampling locations and procedures and have found them to be

_______Acceptable, meet contract requirements.

_______Unacceptable, do not meet contract requirements, Contractor is directed to resample.

By: Contracting Officer's Representative

Signature Date

Print Name and Title____

INDIVIDUAL WORK TASK DATA ELEMENTS

Sheet ______ of ______

There is a separate data sheet for each individual work task.

WORK TASK DESIGNATION NUMBER: ________

1. LOCATION OF WORK TASK:

2. BRIEF DESCRIPTION OF THE ABATEMENT ACTIVITY:

-- End of Section --

SECTION 03 11 13.00 10

STRUCTURAL CAST-IN-PLACE CONCRETE FORMING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 347	(2004; Errata 2008) Guide to Formwork for Concrete

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995; R 2004) Basic Hardboard

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood

ASTM INTERNATIONAL (ASTM)

ASTM C1077	(2014) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C578	(2011be1) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3110	(2007) Plywood for Concrete Form
KS F 8006	(2009) Steel Framed Plywood Form

1.2 SYSTEM DESCRIPTION

The design, engineering, and construction of the formwork are the responsibility of the Contractor. Design formwork in accordance with methodology of ACI 347 for anticipated loads, lateral pressures, and stresses, and capable of withstanding the pressures resulting from placement and vibration of concrete. Comply with the tolerances specified in Section 03 30 00 CAST-IN-PLACE CONCRETE paragraph CONSTRUCTION TOLERANCES. However, for surfaces with an ACI Class A surface designation, limit the allowable deflection for facing material between studs, for studs between walers and walers between bracing to 0.0025 times the span. Design the formwork as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. Monitor the adequacy of formwork design and construction prior to and during concrete placement as part of the Contractor's approved Quality Control Plan. Submit design analysis and calculations for form design and methodology used in the design.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Formwork

SD-03 Product Data

Design
Form Materials

1.4 QUALITY ASSURANCE

Sample Panels shall be of sufficient size to contain joints and shall be not less than 2 meters long and 1.5 meters wide (6 feet long and 4 feet wide). The panels shall be of typical wall thickness and constructed containing the full allocation of reinforcing steel that will be used in the structure, with the forming system that duplicates in every detail the one that will be used in construction of the structure. Use the same concrete mixture proportion and materials, the same placement techniques and equipment, and the same finishing techniques and timing that are planned for the structure. Construction of Class A finish will not be permitted until sample panels have been approved. Protect sample panels from construction operations in a manner to protect approved finish, and are not to be removed until all Class A finish concrete has been accepted. After shop drawings have been reviewed, submit sample panels for Class A finish with applied architectural treatment; panels shall be built on the project site where directed.

1.5 DELIVERY, STORAGE, AND HANDLING

Store fiber voids above ground level in a dry location. Fiber voids shall be kept dry until installed and overlaid with concrete.

PART 2 PRODUCTS

2.1 FORM MATERIALS

Submit manufacturer's data, including literature describing form materials, accessories, and form releasing agents.

2.1.1 Forms For Class A Finish

Forms for Class A finished surfaces shall be plywood panels conforming to APA L870, Grade B-B concrete form panels, Class I or II, or KS F 3110 or KS F 8006. Other form materials or liners may be used provided the smoothness and appearance of concrete produced will be equivalent to that produced by the plywood concrete form panels. Forms for round columns shall be the prefabricated seamless type.

2.1.2 Forms For Class B Finish

This class of finish shall apply to all surfaces except those specified to receive Class A, Class C, and Class D. Forms for Class B finished surfaces shall be plywood panels conforming to APA L870, Grade B-B concrete form panels, Class I or II, KS F 3110, or KS F 8006. Other form materials or liners may be used provided the smoothness and appearance of concrete produced will be equivalent to that produced by the plywood concrete form panels. Forms for round columns shall be the prefabricated seamless type. Steel lining on wood sheathing will not be permitted.

2.1.3 Forms For Class C Finish

Forms for Class C finished surfaces shall be shiplap lumber; plywood conforming to APA L870, Grade B-B concrete form panels, Class I or II; tempered concrete form hardboard conforming to AHA A135.4, KS F 3110, or KS F 8006; other approved concrete form material; or steel, except that steel lining on wood sheathing shall not be used. Forms for round columns may have one vertical seam.

2.1.4 Forms For Class D Finish

Forms for Class D finished surfaces, except where concrete is placed against earth, shall be wood or steel or other approved concrete form material.

2.1.5 Retain-In-Place Metal Forms

Retain-in-place metal forms for concrete slabs and roofs shall be as specified in Section 05 30 00 STEEL DECKS.

2.1.6 Pan-Form Units

Pan-form units for one-way or two-way concrete joist and slab construction shall be factory-fabricated units of the approximate section indicated. Units shall consist of steel or molded fiberglass concrete form pans. Closure units shall be furnished as required.

2.1.7 Form Ties

Form ties shall be factory-fabricated metal ties, shall be of the removable or internal disconnecting or snap-off type, and shall be of a design that will not permit form deflection and will not spall concrete upon removal. Provide solid backing for each tie. Except where removable tie rods are used, ties shall not leave holes in the concrete surface less than 6 mm (1/4 inch) or more than 25 mm (1 inch) deep and not more than 25 mm (1 inch) in diameter. Terminate the embedded portion of metal ties not less that 50 mm (2 inches) from any concrete surface exposed to water. Removable tie rods shall be not more than 38 mm (1-1/2 inches) in diameter. Plastic snap ties may be used in locations where the surface will not be exposed to view.

2.1.8 Form Releasing Agents

Form releasing agents shall be commercial formulations that will not bond with, stain or adversely affect concrete surfaces. Agents shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, follow the recommendation of the form coating manufacturer. Submit manufacturer's recommendation on method and rate of application of form releasing agents.

2.1.9 Fiber Voids

Fiber voids shall be the product of a reputable manufacturer regularly engaged in the commercial production of fiber voids. The voids shall be constructed of double faced, corrugated fiberboard. The corrugated fiberboard shall be fabricated of wet strength, or standard kraft paper liners, impregnated with paraffin, and laminated with moisture resistant adhesive, and shall have a board strength of 20 kg/square centimeter (275 psi). Voids which are impregnated with paraffin after construction, in lieu of being constructed with paraffin impregnated fiberboard, are acceptable. Voids shall be designed to support not less than 4900 kg/square meter (1000 psf). To prevent separation during concrete placement fiber voids shall be assembled with steel or plastic banding at 1.22 m (4 feet) on center maximum, or by adequate stapling or gluing as recommended by the manufacturer. Fiber voids placed under concrete slabs and that are 200 mm (8 inches) in depth may be heavy duty "waffle box" type, constructed of paraffin impregnated corrugated fiberboard. Submit one sample unit of fiber voids prior to installation of the voids and certificates attesting that fiber voids conform to the specified requirements.

2.2 FIBER VOID RETAINERS

2.2.1 Polystyrene Rigid Insulation

Polystyrene rigid insulation shall conform to ASTM C578, Type V, VI, or VII, square edged. Size shall be 38 mm (1-1/2 inches) thick by 400 mm (16 inches) in height by 1 m (3 feet) in length, unless otherwise indicated.

2.2.2 Precast Concrete

Precast concrete units shall have a compressive strength of not less than 17 MPa (2500 psi), reinforced with 150 mm by 150 mm by W1.4 WWF (6 inch by 6 inch by W1.4 WWF) wire mesh, and 300 mm (height) by 1 m (length) by 40 mm (thickness) (12 inches (height) by 3 feet (length) by 1-5/8 inches (thickness)) in size unless indicated.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Formwork

Forms shall be constructed true to the structural design and required alignment. Forms shall be mortar tight, properly aligned and adequately supported to produce concrete surfaces meeting the surface requirements specified in Section 03 30 00 CAST-IN-PLACE CONCRETE and conforming to construction tolerance given in TABLE 1. Continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface class specified. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. Where concrete surfaces are to have a Class A or Class B finish, joints in form panels shall be arranged as approved. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse. Form ties that are to be completely withdrawn shall be coated with a nonstaining bond breaker. Submit drawings showing details of formwork, including dimensions of fiber voids, joints, supports, studding and shoring, and sequence of form and shoring removal.

3.1.2 Fiber Voids

Voids shall be placed on a smooth firm dry bed of suitable material, to avoid being displaced vertically, and shall be set tight, with no buckled cartons, in order that horizontal displacement cannot take place. Each section of void shall have its ends sealed by dipping in paraffin, with any additional cutting of voids at the jobsite to be field dipped in the same type of sealer, unless liners and flutes are completely impregnated with paraffin. Prior to placing reinforcement, the entire formed area for slabs shall be covered with a 1.22 x 2.44 m (4 x 8 feet) minimum flat sheets of fiber void corrugated fiberboard. Joints shall be sealed with a moisture resistant tape having a minimum width of 75 mm (3 inches). If voids are destroyed or damaged and are not capable of supporting the design load, they shall be replaced prior to placing of concrete.

3.1.3 Fiber Void Retainers

Fiber void retainers shall be installed, continuously, on both sides of fiber voids placed under grade beams in order to retain the cavity after the fiber voids biodegrade.

3.2 CHAMFERING

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rock fill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 300 mm (twelve inches) outside the limit of the earth or rock fill so that the end of the chamfers will be clearly visible.

3.3 COATING

Forms for Class A and Class B finished surfaces shall be coated with a form releasing agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's printed or written instructions. Forms for Class C and D finished surfaces may be wet with water in lieu of coating immediately before placing concrete, except that in cold weather with probable freezing temperatures, coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.4 FORM REMOVAL

Forms shall not be removed without approval. The minimal time required for concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. Contractor shall consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum time, minimum ambient temperature, and minimum compressive strength requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C31/C31M and ASTM C39/C39M at the expense of the Contractor by an independent laboratory that complies with ASTM C1077 and shall be tested within 4 hours after removal from the site.

3.4.1 Formwork Not Supporting Weight of Concrete

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed. If forms are to be removed in less than 24 hours on formwork not supporting the weight of concrete, evaluation and results of the control cylinder tests shall be submitted and approved before the forms are removed.

3.4.2 Formwork Supporting Weight of Concrete

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders indicate evidence the concrete has attained at least 70 percent of the compressive strength required for the structure in accordance with the quality and location requirements.

3.4.3 Tunnel Forms

Tunnel lining bulkhead forms shall not be removed in less than 12 hours and tunnel lining forms in not less than 16 hours.

3.5 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing. Submit field inspection reports for concrete forms and embedded items.

TABLE 1
TOLERANCES FOR FORMED SURFACES

1. Variations from the plumb:	
a. In the lines and surfaces of columns, piers, walls and in arises	6 mm in any 3 m (1/4 inch in any 10 feet) of length Maximum for entire length -- 25 mm (1 inch)
b. For exposed corner columns, control-joint grooves, and other conspicuous lines	6 mm in any 6 m (1/4 inch in any 20 feet) of length Maximum for entire length -- 13 mm (1/2 inch)
2. Variation for the level or from the grades indicated on the drawings:	
a. In slab soffits, ceilings beam soffits, and in arises, measured before removal of supporting shores	6 mm in any 3 m (1/4 inch in any 10 feet) of length 10 mm (3/8 inch) in any bay or in any 6 m (20 feet) of length Maximum for entire length -- 20 mm (3/4 inch)
b. In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines	6 mm (1/4 inch) in any bay or in any 6 m (20 feet) of length Maximum for entire length -- 13 mm (1/2 inch)
3. Variation of the linear building lines from established position in plan	13 mm in any 6 m (1/2 inch in any 10 feet) 25 mm (1 inch) maximum
4. Variation of distance between walls, columns, partitions	6 mm per 3 m (1/4 inch per 10 feet) of distance, but not more than 13 mm (1/2 inch) in any one bay, and not more than 25 mm (1 inch) total variation

TABLE 1 TOLERANCES FOR FORMED SURFACES	
5. Variation in the sizes and locations of sleeves, floor openings, and wall opening	Minus 6 mm (1/4 inch), Plus 13 mm (1/2 inch)
6. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	Minus 6 mm (1/4 inch), Plus 13 mm (1/2 inch)
7. Footings:	
a. Variation of dimensions in plan	Minus 13 mm (1/2 inch), plus 50 mm (2 inches) when formed or plus 75 mm (3 inches) when placed against unformed excavation
b. Misplacement of eccentricity	2 percent of the footing width in the direction of misplacement but not more than 50 mm (2 inches)
c. Reduction in thickness	Minus 5 percent of the specified thickness
8. Variation in steps:	
a. In a flight of stairs	Riser -- 3 mm (1/8 inch) Tread -- 6 mm (1/4 inch)
b. In consecutive steps	Riser -- 2 mm (1/16 inch) Tread -- 3 mm (1/8 inch)

-- End of Section --

SECTION 03 15 00.00 10

CONCRETE ACCESSORIES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 111	(2011) Standard Method of Test for Mineral Matter or Ash in Asphalt Materials

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995; R 2004) Basic Hardboard

ASTM INTERNATIONAL (ASTM)

ASTM A1011/A1011M	(2014) Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
ASTM A109/A109M	(2008) Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A480/A480M	(2012) Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM B152/B152M	(2013) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B370	(2012) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM C919	(2008) Use of Sealants in Acoustical Applications
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants

ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2628	(1991; R 2011) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	(1989; R 2007) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D4	(1986; R 2010) Bitumen Content
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2012) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D5249	(2010) Backer Material for Use with Cold-and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D6/D6M	(1995e1; R 2011) Loss on Heating of Oil and Asphaltic Compounds
ASTM D7116	(2005) Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavement

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 5201	(2009) Copper and Copper Alloy Sheets, Plates and Strips
KS F 2538	(2005) Specification for preformed expansion joint fillers for concrete paving and structural construction

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Preformed Expansion Joint Filler
Sealant
Waterstops

1.3 DELIVERY, STORAGE, AND HANDLING

Protect material delivered and placed in storage off the ground from moisture, dirt, and other contaminants. Deliver sealants in the manufacturer's original unopened containers. Remove sealants from the site whose shelf life has expired.

PART 2 PRODUCTS

2.1 CONTRACTION JOINT STRIPS

Contraction joint strips shall be 3 mm (1/8 inch) thick tempered hardboard conforming to AHA A135.4, Class 1. In lieu of hardboard strips, rigid polyvinylchloride (PVC) or high impact polystyrene (HIPS) insert strips specifically designed to induce controlled cracking in slabs on grade may be used. Such insert strips shall have removable top section.

2.2 PREFORMED EXPANSION JOINT FILLER

Expansion joint filler shall be preformed material conforming to ASTM D1751, ASTM D1752, or KS F 2538. Unless otherwise indicated, filler material shall be 10 mm (3/8 inch) thick and of a width applicable for the joint formed. Backer material, when required, shall conform to ASTM D5249.

2.3 SEALANT

Joint sealant shall conform to the following:

2.3.1 Preformed Polychloroprene Elastomeric Type

ASTM D2628.

2.3.2 Lubricant for Preformed Compression Seals

ASTM D2835.2.3.3 Field-Molded Type

ASTM C920. Sealant shall be Type M, Grade P or NS, Class 25, Use NT for horizontal joints. Type M, Grade NS, Class 25, Use NT for vertical joints. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, non-shrink, nonreactive with sealant, and non-absorptive material type such as extruded butyl or polychloroprene rubber.

2.3.4 Hot-Applied Jet-Fuel Resistant Type

ASTM D7116, Type I, II, or III, as indicated.

2.4 WATERSTOPS

Shop fabricate intersection and change of direction waterstops.

2.4.1 Flexible Metal

Copper waterstops shall conform to ASTM B152/B152M, ASTM B370, or KS D 5201, O60 soft anneal temper and 0.686 mm (20 oz mass per sq ft) sheet thickness. Stainless steel waterstops shall conform to ASTM A167 and ASTM A480/A480M, UNS S30453 (Type 304L), and 0.9525 mm (0.0375 inch) thick strip.

2.4.2 Rigid Metal

Flat steel waterstops shall conform to ASTM A109/A109M, No. 2 (half hard) temper, No. 2 edge, No. 1 (matte or dull) finish or ASTM A1011/A1011M, Grade 40.

2.4.3 Non-Metallic Materials

Non-metallic waterstops shall be manufactured from a prime virgin resin; reclaimed material is not acceptable. The compound shall contain plasticizers, stabilizers, and other additives to meet specified requirements. Rubber waterstops shall conform to COE CRD-C 513. Polyvinylchloride waterstops shall conform to COE CRD-C 572. Thermoplastic elastomeric rubber waterstops shall conform to ASTM D471.

2.4.4 Non-Metallic Hydrophilic

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water shall conform to ASTM D412 as follows: Tensile strength 2.9 MPa (420 psi) minimum; ultimate elongation 600 percent minimum. Hardness shall be 50 minimum on the type A durometer and the volumetric expansion ratio in distilled water at 20 degrees C (70 degrees F) shall be 3 to 1 minimum.

2.4.5 Preformed Elastic Adhesive

Produce preformed plastic adhesive waterstops from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler, containing no solvents, asbestos, irritating fumes or obnoxious odors. The compound shall not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength.

2.4.5.1 Chemical Composition

Meet the chemical composition of the sealing compound requirements shown below:

PERCENT BY WEIGHT			
COMPONENT	MINIMUM	MAXIMUM	TEST
Bitumen (Hydrocarbon plastic)	50	70	ASTM D4

PERCENT BY WEIGHT			
COMPONENT	MINIMUM	MAXIMUM	TEST
Inert Mineral Filler	30	50	AASHTO T 111
Volatile Matter		2	ASTM D6/D6M

2.4.5.2 Adhesion Under Hydrostatic Pressure

The sealing compound shall not leak at the joints for a period of 24 hours under a vertical 2 m (6 foot) head pressure. In a separate test, the sealing compound shall not leak under a horizontal pressure of 65 kPa (10 psi) which is reached by slowly applying increments of 13 kPa (2 psi) every minute.

2.4.5.3 Sag of Flow Resistance

Sagging shall not be detected when tested as follows: Fill a wooden form 25 mm (1 inch) wide and 150 mm (6 inches) long flush with sealing compound and place in an oven at 58 degrees C (135 degrees F) in a vertical position for 5 days.

2.4.5.4 Chemical Resistance

The sealing compound when immersed separately in a 5% solution of caustic potash, a 5% solution of hydrochloric acid, 5% solution of sulfuric acid and a saturated hydrogen sulfide solution for 30 days at ambient room temperature shall show no visible deterioration.

2.5 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Joint locations and details, including materials and methods of installation of joint fillers and waterstops, shall be as specified and indicated. In no case shall any fixed metal be continuous through an expansion or contraction joint.

3.1.1 Contraction Joints

Contraction joints may be constructed by inserting tempered hardboard strips or rigid PVC or HIPS insert strips into the plastic concrete using a steel parting bar, when necessary, or by cutting the concrete with a saw after concrete has set. Make joints 3 mm to 5 mm (1/8 inch to 3/16 inch) wide and extend into the slab one-fourth the slab thickness, minimum, but not less than 25 mm (1 inch).

3.1.1.1 Joint Strips

Provide strips of the required dimensions and as long as practicable. After the first floating, groove the concrete with a tool at the joint locations. Insert the strips in the groove and depress them until the top edge of the vertical surface is flush with the surface of the slab. Float and finish the slab as specified. Working of the concrete adjacent to the joint shall be the minimum necessary to fill voids and consolidate the concrete. Where indicated, saw out the top portion of the strip after the curing period to form a recess for sealer. Discard the removable section of PVC or HIPS strips and leave the insert in place. Maintain true alignment of the strips during insertion.

3.1.1.2 Sawed Joints

Saw joints early enough to prevent uncontrolled cracking in the slab, but late enough that this can be accomplished without appreciable spalling. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent raveling of the edges of the saw cut. Cutting shall be completed before shrinkage stresses become sufficient to produce cracking. Use concrete sawing machines that are adequate in number and power, and with sufficient replacement blades to complete the sawing at the required rate. Cut joints to true alignment and in sequence of concrete placement. Remove sludge and cutting debris. Form reservoir for joint sealant.

3.1.2 Expansion Joints

Use preformed expansion joint filler in expansion and isolation joints in slabs around columns and between slabs on grade and vertical surfaces where indicated. Extend the filler to the full slab depth, unless otherwise indicated. neatly finish the edges of the joint with an edging tool of 3 mm (1/8 inch) radius, except where a resilient floor surface will be applied. Where the joint is to receive a sealant, the filler strips shall be installed at the proper level below the finished floor with a slightly tapered, dressed and oiled wood strip temporarily secured to the top to form a recess to the size shown on the drawings. Remove the wood strip after the concrete has set. Contractor may opt to use a removable expansion filler cap designed and fabricated for this purpose in lieu of the wood strip. Thoroughly clean the groove of laitance, curing compound, foreign materials, protrusions of hardened concrete, and any dust. If blowing out the groove use oil-free compressed air.

3.1.3 Joint Sealant

Fill sawed contraction joints and expansion joints in slabs with joint sealant, unless otherwise shown. Joint surfaces shall be clean, dry, and free of oil or other foreign material which would adversely affect the bond between sealant and concrete. Apply joint sealant as recommended by the manufacturer of the sealant.

3.1.3.1 Joints With Preformed Compression Seals

Install compression seals with equipment capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal or concrete and with no more than 5 percent stretching of the seal. Cover the sides of the joint and, if necessary, the sides of the compression seal with a coating of lubricant. Coat butt joints with liberal applications of lubricant.

3.1.3.2 Joints With Field-Molded Sealant

Do not seal joints when the sealant material, ambient air, or concrete temperature is less than 4 degrees C (40 degrees F). When the sealants are meant to reduce the sound transmission characteristics of interior walls, ceilings, and floors the guidance provided in ASTM C919 shall be followed. Coat joints requiring a bond breaker with curing compound or with bituminous paint. Install bond breaker and back-up material where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.2 WATERSTOPS, INSTALLATION AND SPLICES

Install waterstops at the locations shown to form a continuous water-tight diaphragm. Make adequate provision to support and completely protect the waterstops during the progress of the work. Repair or replace any waterstop punctured or damaged. Protect exposed waterstops during application of form release agents to avoid being coated. Provide suitable guards to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued. Accomplish splices with certified trained personnel using approved equipment and procedures.

3.2.1 Copper And Stainless Steel

Splices in copper waterstops shall be lap joints made by brazing. Splices in stainless steel waterstops shall be welded using a TIG or MIG process utilizing a weld rod to match the stainless. All welds shall not be annealed to maintain physical properties. Do not use carbon flame in the annealing process. Damaged waterstops shall be repaired by removing damaged portions and patching. Patches shall overlap a minimum of 25 mm (1 inch) onto undamaged portion of the water stop.

3.2.2 Flat Steel

Splices in flat steel waterstops shall be properly aligned, butt welded, and cleaned of excessive material.

3.2.3 Non-Metallic

Fittings shall be shop made using a machine specifically designed to mechanically weld the water stop. A miter guide, proper fixturing (profile dependant), and portable power saw shall be used to miter cut the ends to be joined to ensure good alignment and contact between joined surfaces. The splicing of straight lengths shall be done by squaring the ends to be joined. Maintain continuity of the characteristic features of the cross section of the water stop (ribs, tabular center axis, protrusions, etc.) across the splice.

3.2.3.1 Rubber Water stop

Splices shall be vulcanized or shall be made using cold bond adhesive as recommended by the manufacturer. Splices for TPE-R shall be as specified for PVC.

3.2.3.2 Polyvinyl Chloride Water stop

Make splices by heat sealing the adjacent water stop edges together using a thermoplastic splicing iron utilizing a non-stick surface specifically designed for water stop welding. Use the correct temperature to sufficiently melt without charring the plastic. Reform waterstops at splices with a remolding iron with ribs or corrugations to match the pattern of the water stop. The spliced area, when cooled, shall show no signs of separation, holes, or other imperfections when bent by hand in as sharp an angle as possible.

3.2.3.3 Quality Assurance

Edge welding will not be permitted. Compress or close center bulbs when welding to non-center bulb type. Waterstop splicing defects which are unacceptable include, but are not limited to the following: 1) Tensile strength less than 80 percent of parent section. 2) Free lap joints. 3) Misalignment of center bulb, ribs, and end bulbs greater than 2 mm (1/16 inch). 4) Misalignment which reduces waterstop cross section more than 15 percent. 5) Bond failure at joint deeper than 2 mm (1/16 inch) or 15 percent of material thickness. 6) Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 13 mm in 3 m (1/2 inch in 10 feet). 7) Visible porosity in the weld area, including pin holes. 8) Charred or burnt material. 9) Bubbles or inadequate bonding. 10) Visible signs of splice separation when cooled splice is bent by hand at a sharp angle.

3.2.4 Non-Metallic Hydrophilic Waterstop Installation

Miter cut ends to be joined with sharp knife or shears. The ends shall be adhered with cyanacryiate (super glue) adhesive. When joining hydrophilic type waterstop to PVC waterstop, the hydrophilic waterstop shall be positioned as shown on the drawings. Apply a liberal amount of a single component hydrophilic sealant to the junction to complete the transition.

3.2.5 Preformed Plastic Adhesive Installation

The installation of preformed plastic adhesive waterstops shall be a prime, peel, place and pour procedure. Joint surfaces shall be clean and dry before priming and just prior to placing the sealing strips. The end of each strip shall be spliced to the next strip with a 25 mm (1 inch) overlap; the overlap shall be pressed firmly to release trapped air. During damp or cold conditions the joint surface shall be flashed with a safe, direct flame to warm and dry the surface adequately; the sealing strips shall be dipped in warm water to soften the material to achieve maximum bond to the concrete surface.

3.3 CONSTRUCTION JOINTS

Treat construction joints coinciding with expansion and contraction joints as expansion or contraction joints as applicable.

-- End of Section --

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CONCRETE REINFORCING
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318	(2011; Errata 2011) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A1035/A1035M	(2011) Standard Specification for Deformed and Plain, Low-carbon, Chromium, Steel Bars for Concrete Reinforcement
ASTM A184/A184M	(2006; E2011) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A496/A496M	(2007) Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A497/A497M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A675/A675M	(2003; R 2009) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
ASTM A706/A706M	(2009b) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767/A767M	(2009) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A82/A82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A884/A884M	(2006) Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A934/A934M	(2007) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM C1116/C1116M	(2010a) Standard Specification for Fiber-Reinforced Concrete

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP	(2009; 28th Ed) Manual of Standard Practice

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3503	(2008) Rolled Steels for General Structure
KS D 3504	(2011) Steel Bars for Concrete Reinforcement
KS D 3629	(2005) Fusion Bonded Epoxy Coated Reinforcing Steel Bars
KS D 7017	(2007) Welded Steel Wire Fabrics

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Reinforcement

SD-03 Product Data

Epoxy-Coated Bars

SD-07 Certificates

Welding Qualifications
Reinforcing Steel

1.3 QUALITY ASSURANCE

1.3.1 Welding Qualifications

Welders shall be qualified in accordance with AWS D1.4/D1.4M. Qualification test shall be performed at the worksite and notify the Contracting Officer 24 hours prior to conducting tests. Special welding procedures and welders qualified by others may be accepted as permitted by AWS D1.4/D1.4M. Submit a list of qualified welders' names.

1.3.2 Qualification of Steel Bar Butt-Splicers

Qualification of steel bar butt-splicers shall be certified to have satisfactorily completed a course of instruction in the proposed method of butt-splicing or have satisfactorily performed such work within the preceding year. Submit certificates on the Qualifications of Steel Bar Butt-Splicers prior to commencing butt-splicing.

1.3.3 Qualification of Butt-Splicing Procedure

As a condition of approval of the butt-splicing procedure, make three test butt-splices of steel bars of each size to be spliced using the proposed butt-splicing method, in the presence of the Contracting Officer. These test butt-splices and unspliced bars of the same size shall be tension tested to destruction with stress-strain curves plotted for each test. Test results shall show that the butt-splices meet the specified strength and deformation requirements in order for the splicing procedure to be approved.

1.4 DELIVERY, STORAGE, AND HANDLING

Reinforcement and accessories shall be stored off the ground on platforms, skids, or other supports.

PART 2 PRODUCTS

2.1 DOWELS

Dowels shall conform to ASTM A675/A675M, Grade 80, or KS D 3503, SS540 or SS490. Steel pipe conforming to ASTM A53/A53M, Schedule 80, may be used as dowels provided the ends are closed with metal or plastic inserts or with mortar.

2.2 FABRICATED BAR MATS

Fabricated bar mats shall conform to ASTM A184/A184M.

2.3 REINFORCING STEEL

Reinforcing steel shall be deformed bars conforming to ASTM A615/A615M, ASTM A706/A706M, ASTM A1035/A1035M, or KS D 3504 grades and sizes as indicated. Cold drawn wire used for spiral reinforcement shall conform to ASTM A82/A82M. In highly corrosive environments or when directed by the Contracting Officer, reinforcing steel shall conform to ASTM A767/A767M, ASTM A775/A775M, ASTM A1035/A1035M, ASTM A934/A934M, or KS D 3629, as appropriate.

2.3.1 Zinc-Coated (Galvanized) Bars

Zinc-coated (galvanized) bars shall comply with the requirements of ASTM A767/A767M, Coating Class as indicated , galvanized after fabrication.

2.3.2 Epoxy-Coated Bars

Epoxy-coated steel bars shall comply with the requirements of ASTM A775/A775M or ASTM A934/A934M as applicable, including written certifications for coating material and coated bars.

2.4 WELDED WIRE FABRIC

Welded wire fabric shall conform to ASTM A185/A185M, ASTM A496/A496M, ASTM A497/A497M, or KS D 7017. When directed by the Contracting Officer for special applications, welded wire fabric shall conform to ASTM A884/A884M.

2.5 WIRE TIES

Wire ties shall be 16 gauge or heavier black annealed steel wire. Ties for epoxy-coated bars shall be vinyl-coated or epoxy-coated. Ties for zinc-coated bars shall be zinc-coated.

2.6 SUPPORTS

Bar supports for formed surfaces shall be designed and fabricated in accordance with CRSI 10MSP and shall be steel or precast concrete blocks. Precast concrete blocks shall have wire ties and shall be not less than 100 by 100 mm (4 inches square) when supporting reinforcement on ground. Precast concrete block shall have compressive strength equal to that of the surrounding concrete. Where concrete formed surfaces will be exposed to weather or where surfaces are to be painted, steel supports within 13 mm (1/2 inch) of concrete surface shall be galvanized, plastic protected or of stainless steel. Concrete supports used in concrete exposed to view shall have the same color and texture as the finish surface. For slabs on grade, supports shall be precast concrete blocks, plastic coated steel fabricated with bearing plates, or specifically designed wire-fabric supports fabricated of plastic.

2.7 SYNTHETIC FIBER REINFORCEMENT

Synthetic fiber shall be polypropylene with a denier less than 100 and a nominal fiber length of 50 mm (2 inches).

PART 3 EXECUTION

3.1 REINFORCEMENT

Reinforcement steel and accessories shall be fabricated and placed as specified and as shown on approved shop drawings. Fabrication and placement details of steel and accessories not specified or shown shall be in accordance with ACI SP-66 and ACI 318M (ACI 318). Reinforcement shall be cold bent unless otherwise authorized. Bending may be accomplished in the field or at the mill. Zinc-Coated and epoxy-coated bars shall be mill-bent prior to coating. All steel shall be bent cold unless authorized by Contracting Officer Representative. Bars shall not be bent after embedment in concrete. Safety caps shall be placed on all exposed ends of vertical concrete reinforcement bars that pose a danger to life safety. Wire tie ends shall face away from the forms. Submit detail drawings showing reinforcing steel placement, schedules, sizes, grades, and splicing and bending details. Drawings shall show support details including types, sizes and spacing.

3.1.1 Placement

Reinforcement shall be free from loose rust and scale, dirt, oil, or other deleterious coating that could reduce bond with the concrete. Reinforcement shall be placed in accordance with ACI 318M (ACI 318) at locations shown plus or minus one bar diameter. Reinforcement shall not be continuous through expansion joints and shall be as indicated through construction or contraction joints. Concrete coverage shall be as indicated or as required by ACI 318M (ACI 318). If bars are moved more than one bar diameter to avoid interference with other reinforcement, conduits or embedded items, the resulting arrangement of bars, including additional bars required to meet structural requirements, shall be approved before concrete is placed.

3.1.2 Splicing

Splices of reinforcement shall conform to ACI 318M (ACI 318) and shall be made only as required or indicated. Splicing shall be by lapping or by mechanical or welded butt connection; except that lap splices shall not be used for bars larger than No. 11 unless otherwise indicated. Welding shall conform to AWS D1.4/D1.4M. Welded butt splices shall be full penetration butt welds. Lapped bars shall be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than one-fifth the required length of lap or 150 mm (6 inches). Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line.

3.2 WELDED-WIRE FABRIC PLACEMENT

Welded-wire fabric shall be placed in slabs as indicated. Fabric placed in slabs on grade shall be continuous between expansion, construction, and contraction joints. Fabric placement at joints shall be as indicated. Lap splices shall be made in such a way that the overlapped area equals the distance between the outermost crosswires plus 50 mm (2 inches). Laps shall be staggered to avoid continuous laps in either direction. Fabric shall be wired or clipped together at laps at intervals not to exceed 1.2 m (4 feet). Fabric shall be positioned by the use of supports.

3.3 DOWEL INSTALLATION

Dowels shall be installed in slabs on grade at locations indicated and at right angles to joint being doweled. Dowels shall be accurately positioned and aligned parallel to the finished concrete surface before concrete placement. Dowels shall be rigidly supported during concrete placement. One end of dowels shall be coated with a bond breaker.

3.4 SYNTHETIC FIBER REINFORCED CONCRETE

Fiber reinforcement shall be added to the concrete mix in accordance with the applicable sections of ASTM C1116/C1116M and the recommendations of the manufacturer, and in an amount of 0.1 percent by volume.

3.5 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

Special inspections and testing for seismic-resisting systems and components shall be done in accordance with UFC 3-310-04.

-- End of Section --

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats
AASHTO M 322M/M 322	(2010) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI/MCP-1	(2012) Manual of Concrete Practice Part 1
ACI/MCP-2	(2012) Manual of Concrete Practice Part 2
ACI/MCP-3	(2012) Manual of Concrete Practice Part 3
ACI/MCP-4	(2012) Manual of Concrete Practice Part 4

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995; R 2004) Basic Hardboard

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A496/A496M	(2007) Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A497/A497M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for

	Concrete
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M	(2009b) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767/A767M	(2009) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A82/A82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A934/A934M	(2007) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A996/A996M	(2009b) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1107/C1107M	(2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2010a) Standard Specification for Fiber-Reinforced Concrete
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C156	(2011) Standard Test Method for Water Retention by Concrete Curing Materials
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2010) Standard Practice for Sampling

	Freshly Mixed Concrete
ASTM C173/C173M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M	(2014) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C233/C233M	(2011) Standard Test Method for Air-Entraining Admixtures for Concrete
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C311	(2011b) Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C330/C330M	(2009) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2012) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C567/C567M	(2011) Determining Density of Structural Lightweight Concrete
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881/C881M	(2013) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C932	(2006) Standard Specification for Surface-Applied Bonding Compounds for Exterior Plastering
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2013) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C990	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2628	(1991; R 2011) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D5759	(1995; R 2005) Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses
ASTM D6690	(2012) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D7116	(2005) Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavement
ASTM E1155	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers

ASTM E1745	(2011) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
ASTM E329	(2011c) Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP	(2009; 28th Ed) Manual of Standard Practice

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(2009) DOC Voluntary Product Standard PS 1-07, Structural Plywood

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

U.S. DEPARTMENT OF COMMERCE (DOC)

DOC/NIST PS1	(1995) Construction and Industrial Plywood with Typical APA Trademarks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement
FS UU-B-790	(Rev A; Am 1; Notice 1) Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2401	(2007) Method of Sampling Fresh Concrete
KS F 2402	(2007) Slump of Concrete
KS F 2403	(2014) Making and Curing Concrete Specimens
KS F 2405	(2010) Compressive Strength of Concrete
KS F 2422	(2007) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
KS F 2425	(2002) Making Test Sample of Concrete in Laboratory
KS F 2526	(2007) Aggregate for Concrete
KS F 2538	(2005) Specification for preformed

	expansion joint fillers for concrete paving and structural construction
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 4009	(2011) Ready-Mixed Concrete
KS L 5201	(2013) Portland Cement
KS L 5508	(2007) Fly Ash and Other Pozzolans for Use with Lime
KS M 3354	(2006) Polytetrafluoroethylene Coated Dry Film

1.2 DEFINITIONS

a. "Cementitious material" as used herein must include all portland cement, pozzolan, fly ash, ground granulated blast-furnace slag, and silica fume.

b. "Exposed to public view" means situated so that it can be seen from eye level from a public location after completion of the building. A public location is accessible to persons not responsible for operation or maintenance of the building.

c. "Chemical admixtures" are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes.

d. "Workability (or consistence)" is the ability of a fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, chemical admixtures, aggregate (shape and size distribution), cementitious content and age (level of hydration).

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings
Reinforcing steel; G
Synthetic reinforcing fibers

SD-03 Product Data

Portland Cement
Ready-Mix Concrete
Bonding Materials
Pumping Concrete

Epoxy bonding compound
Waterstops

SD-05 Design Data

Concrete mix design; G
Calculations

SD-06 Test Reports

Concrete mix design; G
Ground granulated blast-furnace slag
Tolerance report
Compressive strength tests
Unit weight of structural lightweight concrete
Air Content
Slump Tests
Temperature Tests
Ion Concentration

SD-07 Certificates

Curing concrete elements
VOC Content for form release agents, curing compounds, and concrete penetrating sealers
Material Safety Data Sheets
Welder Qualifications
Welding Procedures
Classification and Quality of Concrete
Steel Bar

SD-08 Manufacturer's Instructions

Fly ash

1.4 MODIFICATION OF REFERENCES

Accomplish work in accordance with ACI publications except as modified herein. Consider the advisory or recommended provisions to be mandatory. Interpret reference to the "Building Official," the "Structural Engineer," and the "Architect/Engineer" to mean the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING

Do not deliver concrete until vapor retarder, forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. ACI/MCP-2 for job site storage of materials. Protect materials from contaminants such as grease, oil, and dirt. Ensure materials can be accurately identified after bundles are broken and tags removed. Do not store concrete curing compounds or sealers with materials that have a high capacity to adsorb volatile organic compound (VOC) emissions. Do not store concrete curing compounds or sealers in occupied spaces.

1.5.1 Reinforcement

Store reinforcement of different sizes and shapes in separate piles or racks raised above the ground to avoid excessive rusting. Protect from contaminants such as grease, oil, and dirt. Ensure bar sizes can be accurately identified after bundles are broken and tags removed.

1.5.1.1 Epoxy Coated Reinforcing Steel

Record coating lot on each shipping notice and carefully identify and re-tag bar bundles from bending plant. Provide systems for handling coated bars which have padded contact areas, nylon slings, etc., all free of dirt and grit. Lift bundled coated bars with strong back, multiple supports, or platform bridge to prevent sagging and abrasion. Pad bundling bands where in contact with bars. Do not drop or drag bars or bundles. Store coated bars both in shop and in field, aboveground, on wooden or padded cribbing. Space the dunnage close enough to prevent excessive sags. Stack large quantities of straight bars with adequate protective blocking between layers. Schedule deliveries of epoxy coated bars to the job site to avoid the need for long term storage. Protect from direct sunlight and weather. Cover bars to be stored longer than 12 hours at the job site with opaque polyethylene sheeting or other suitable equivalent protective material.

1.6 QUALITY ASSURANCE

1.6.1 Design Data

1.6.1.1 Formwork Calculations

ACI/MCP-4. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components. Furnish drawings and calculations of shoring and re-shoring methods proposed for floor and roof slabs, spandrel beams, and other horizontal concrete members.

1.6.2 Drawings

1.6.2.1 Shop Drawings

Submit fabrication drawings (reproductions of contract drawings are unacceptable) for concrete formwork for Reinforcement Materials, Column Forms, Wall Forms, Floor Forms, Ceiling Forms and for Special Construction must indicate concrete pressure calculations with both live and dead loads, along with material types. Provide all design calculations in accordance with ACI/MCP-2 and ACI/MCP-3.

1.6.2.2 Formwork

Drawings showing details of formwork including, but not limited to; joints, supports, studding and shoring, and sequence of form and shoring removal. Reproductions of contract drawings are unacceptable.

Design, fabricate, erect, support, brace, and maintain formwork so that it is capable of supporting without failure all vertical and lateral loads that may reasonably be anticipated to be applied to the formwork.

1.6.2.3 Reinforcing Steel

ACI/MCP-4. Indicate bending diagrams, assembly diagrams, splicing and laps of bars, shapes, dimensions, and details of bar reinforcing, accessories, and concrete cover. Do not scale dimensions from structural drawings to determine lengths of reinforcing bars.

1.6.3 Control Submittals

1.6.3.1 Curing Concrete Elements

Submit proposed materials and methods for curing concrete elements.

1.6.3.2 Pumping Concrete

Submit proposed materials and methods for pumping concrete. Submittal must include mix designs, pumping equipment including type of pump and size and material for pipe, and maximum length and height concrete is to be pumped.

1.6.3.3 Form Removal Schedule

Submit schedule for form removal indicating element and minimum length of time for form removal.

1.6.3.4 VOC Content for form release agents, curing compounds, and concrete penetrating sealers

Submit certification for the form release agent, curing compounds, and concrete penetrating sealers that indicate the VOC content of each product.

1.6.3.5 Material Safety Data Sheets

Submit Material Safety Data Sheets (MSDS) for all materials that are regulated for hazardous health effects. Prominently post the MSDS at the construction site.

1.6.4 Test Reports

1.6.4.1 Concrete Mix Design

Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, pozzolans, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which produce a range of strength encompassing those required for each class and type of concrete required. If source material changes, resubmit mix proportion data using revised source material. Provide only materials that have been proven by trial mix studies to meet the requirements of this specification, unless otherwise approved in writing by the Contracting Officer. Indicate clearly in the submittal where each mix design is used when more than one mix design is submitted. Submit additional data regarding concrete aggregates if the source of aggregate changes. Submit copies of the fly ash, and pozzolan test results must be within 6 months of submittal date. Obtain acknowledgement of receipt prior to concrete placement.

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix must be suitable for the job conditions. Include mill test and all other test for cement, aggregates, and admixtures in the laboratory test reports. Provide maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Submit test reports along with the concrete mix design. Obtain approval before concrete placement.

1.6.4.2 Fly Ash and Pozzolan

Submit test results in accordance with ASTM C618 or KS L 5508 for fly ash and pozzolan. Submit test results performed within 6 months of submittal date. Submit manufacturer's policy statement on fly ash use in concrete.

1.6.4.3 Ground Granulated Blast-Furnace Slag

Submit test results in accordance with ASTM C989/C989M for ground granulated blast-furnace slag. Submit test results performed within 6 months of submittal date. Submit manufacturer's policy statement on slag use in concrete.

1.6.5 Special Finisher Qualifications

For 35 percent or more fly ash content as a percentage of cementitious materials, finisher must have a minimum of 3 years' experience finishing high-volume fly ash concrete.

1.7 ENVIRONMENTAL REQUIREMENTS

Provide space ventilation according to manufacturer recommendations, at a minimum, during and following installation of concrete curing compound and sealer. Maintain one of the following ventilation conditions during the curing compound/sealer curing period or for 72 hours after installation:

a. Supply 100 percent outside air 24 hours a day.

b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 13 degrees C (55 degrees F) and 29 degrees C (84 degrees F) and humidity is between 30 percent and 60 percent.

c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

1.8 QUALIFICATIONS FOR CONCRETE TESTING SERVICE

Perform concrete testing by an approved laboratory and inspection service experienced in sampling and testing concrete. Testing agency must meet the requirements of ASTM E329.

1.9 QUALIFICATIONS FOR WELDING WORK

Section 05 05 23 WELDING, STRUCTURAL applies to work specified in this section.

Welding procedures must be in accordance with AWS D1.4/D1.4M.

Verify that Welder qualifications are in accordance with AWS D1.4/D1.4M or under an equivalent qualification test approved in advance. Welders are permitted to do only the type of welding for which each is specifically qualified.

1.10 CONCRETE SAMPLING AND TESTING

Testing by the Contractor must include sampling and testing concrete materials proposed for use in the work and testing the design mix for each class of concrete. Perform quality control testing during construction.

Sample and test concrete aggregate materials proposed for use in the work in accordance with ASTM C33/C33M or KS F 2526.

Sample and test portland cement in accordance with ASTM C150/C150M or KS L 5201.

Sample and test air-entraining admixtures in accordance with ASTM C233/C233M.

Testing must be performed by a Grade I Testing Technician.

PART 2 PRODUCTS

2.1 MATERIALS FOR FORMS

Provide wood, plywood, plastic, carton, or steel. Use plywood or steel forms where a smooth form finish is required.

2.1.1 Wood Forms

Use lumber as specified in Section 06 10 00 ROUGH CARPENTRY and as follows. Provide lumber that is square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects. Provide plywood that complies with DOC/NIST PS1, B-B concrete form panels or better or AHA A135.4, hardboard for smooth form lining.

2.1.1.1 Concrete Form Plywood (Standard Rough)

Provide plywood that conforms to NIST PS 1, B-B, concrete form, not less than 16 mm (5/8-inch) thick.

2.1.1.2 Overlaid Concrete Form Plywood (Standard Smooth)

Provide plywood that conforms to NIST PS 1, B-B, high density form overlay, not less than 16 mm (5/8-inch) thick.

2.1.2 Plastic Forms

Plastic lumber as specified in Section 06 10 00 ROUGH CARPENTRY.

2.1.3 Carton Forms

Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete until initial set.

2.1.4 Steel Forms

Provide steel form surfaces that do not contain irregularities, dents, or sags.

2.2 FORM TIES AND ACCESSORIES

The use of wire alone is prohibited. Provide form ties and accessories that do not reduce the effective cover of the reinforcement.

2.2.1 Polyvinylchloride Waterstops

COE CRD-C 572.

2.2.2 Dovetail Anchor Slot

Preformed metal slot approximately 25 by 25 mm (1 by 1 inch) of not less than 22 gage galvanized steel cast in concrete. Coordinate actual size and throat opening with dovetail anchors and provide with removable filler material.

2.3 CONCRETE

2.3.1 Contractor-Furnished Mix Design

ACI/MCP-1, ACI/MCP-2, and ACI/MCP-3 except as otherwise specified. Indicate the compressive strength (f'c) of the concrete for each portion of the structure(s) .

Maximum slump shown above may be increased 25 mm (1 inch) for methods of consolidation other than vibration. Slump may be increased to 200 mm (8 inches) when superplasticizers are used. Provide air entrainment using air-entraining admixture. Provide air entrainment within plus or minus 1.5 percent of the value specified. The water soluble chloride ion concentrations in hardened concrete at ages from 28 to 42 days must not exceed 1.00 . Note (a): Entrapped air must be 3 percent or less.

Proportion concrete mixes for strength at 56 days.

2.3.1.1 Mix Proportions for Normal Weight Concrete

Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified are the responsibility of the Contractor. Base mixture proportions on compressive strength as determined by test specimens fabricated in accordance with ASTM C192/C192M or KS F 2425 and tested in accordance with ASTM C39/C39M or KS F 2405. Samples of all materials used in mixture proportioning studies must be representative of those proposed for use in the project and must be accompanied by the manufacturer's or producer's test report indicating compliance with these specifications. Base trial mixtures having proportions, consistencies, and suitable for the work on methodology described in ACI/MCP-1. In the trial mixture, use at least three different water-cement ratios for each type of mixture, which must produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratio required must be based on equivalent water-cement ratio calculations as determined by the conversion from the weight ratio of water to cement plus pozzolan, and ground granulated blast-furnace slag by weight equivalency method. Design laboratory trial mixture for maximum permitted slump and air content. Each combination of material proposed for use must have separate trial mixture, except for accelerator or retarder use can be provided without separate trial mixture. Report the temperature of concrete in each trial batch. For each water-cement ratio, at least three test cylinders for each test age must be made and cured in accordance with ASTM C192/C192M or KS F 2425 and tested in accordance with ASTM C39/C39M or KS F 2405 for 7 and 28 days. From these results, plot a curve showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, plot a curve showing the relationship between 7 and 28 day strengths.

2.3.1.2 Required Average Strength of Mix Design

The selected mixture must produce an average compressive strength exceeding the specified strength by the amount indicated in ACI/MCP-2. When a concrete production facility has a record of at least 15 consecutive tests, the standard deviation must be calculated and the required average compressive strength must be determined in accordance with ACI/MCP-2. When a concrete production facility does not have a suitable record of tests to establish a standard deviation, the required average strength must follow ACI/MCP-2 requirements.

2.3.2 Ready-Mix Concrete

Provide concrete that meets the requirements of ASTM C94/C94M or KS F 4009.

Ready-mixed concrete manufacturer must provide duplicate delivery tickets with each load of concrete delivered. Provide delivery tickets with the following information in addition to that required by ASTM C94/C94M or KS F 4009:

Type and brand cement

Cement content in 43 kilogram (94-pound) bags per cubic meter (yard) of concrete

Maximum size of aggregate

Amount and brand name of admixtures

Total water content expressed by water/cement ratio

2.3.3 Concrete Curing Materials

2.3.3.1 Absorptive Cover

Provide burlap, cotton mats, and other absorbent materials for curing concrete, as described in ACI 308R or KS M 3354.

2.3.3.2 Moisture-Retaining Cover

Provide waterproof paper cover for curing concrete conforming to ASTM C171 or KS M 3354, regular or white, or polyethylene sheeting conforming to ASTM C171 or KS M 3354, or polyethylene-coated burlap consisting of a laminate of burlap and a white opaque polyethylene film permanently bonded to the burlap; burlap must conform to ASTM C171 or KS M 3354, Class 3, and polyethylene film must conform to ASTM C171 or KS M 3354. When tested for water retention in accordance with ASTM C156, weight of water lost 72 hours after application of moisture retaining covering material must not exceed 0.039 gram per square centimeter of the mortar specimen surface.

2.3.3.3 Membrane-Forming Curing Compound

Provide liquid type compound conforming to ASTM C309, Type 1, clear, Type 1D with fugitive dye for interior work and Type 2, white, pigmented for exterior work, or KS F 2540.

2.4 MATERIALS

2.4.1 Cement

ASTM C150/C150M or KS L 5201, Type I, II, or V. Provide blended cement that consists of a mixture of ASTM C150/C150M, Type II, cement and one of the following materials: ASTM C618 or KS L 5508 pozzolan or fly ash, ASTM C989/C989M ground granulated blast-furnace slag. For portland cement manufactured in a kiln fueled by hazardous waste, maintain a record of source for each batch. For exposed concrete, use one manufacturer for each type of cement, ground slag, fly ash, and pozzolan.

2.4.1.1 Fly Ash and Pozzolan

ASTM C618, Type N, F, or C, or KS L 5508 except that the maximum allowable loss on ignition must be 6 percent for Types N and F. Add with cement. Fly ash content must be a minimum of 15 percent by weight of cementitious material, provided the fly ash does not reduce the amount of cement in the concrete mix below the minimum requirements of local building codes. Where the use of fly ash cannot meet the minimum level, provide the maximum amount of fly ash permissible that meets the code requirements for cement content. Report the chemical analysis of the fly ash in accordance with ASTM C311 or KS F 2403. Evaluate and classify fly ash in accordance with ASTM D5759.

High contents of supplementary cementitious materials can have some detrimental effects on the concrete properties, such as slowing excessively the strength gain rate, and delaying and increasing the difficulty of finishing. The recommended maximum content (by weight of the total cementitious material) for these materials are:

1. For GGBF slag: 50 percent

2. For fly ash or natural pozzolan: 40 percent (25 percent in cold climates)

3. For silica fume: 10 percent

2.4.1.2 Ground Granulated Blast-Furnace Slag

ASTM C989/C989M, Grade 120. Slag content must be a minimum of 25 percent by weight of cementitious material.

2.4.1.3 Portland Cement

Provide cement that conforms to ASTM C150/C150M, Type I, II, or V; or KS L 5201 Class I, II or V. Use one brand and type of cement for formed concrete having exposed-to-view finished surfaces.

2.4.2 Water

Minimize the amount of water in the mix. The amount of water must not exceed 45 percent by weight of cementitious materials (cement plus pozzolans), and in general, improve workability by adjusting the grading rather than by adding water. Water must be fresh, clean, and potable; free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances deleterious to concrete.

2.4.3   Aggregates

ASTM C33/C33M or KS F 2526. Furnish aggregates for exposed concrete surfaces from one source. Provide aggregates that do not contain any substance which may be deleteriously reactive with the alkalis in the cement.

2.4.3.1   Aggregates/Combined Aggregate Gradation (Floor Slabs Only)

ASTM C33/C33M, uniformly graded and as follows: Nominal maximum aggregate size of 25 mm (1 inch). A combined sieve analysis must indicate a well graded aggregate from coarsest to finest with not more than 18 percent and not less than 8 percent retained on an individual sieve, except that less than 8 percent may be retained on coarsest sieve and on No. 50 (0.3mm) sieve, and less than 8 percent may be retained on sieves finer than No. 50 (0.3mm). Provide sand that is at least 50 percent natural sand.

2.4.3.2   Aggregates for Lightweight Concrete

ASTM C330/C330M.

2.4.4   Nonshrink Grout

ASTM C1107/C1107M.

2.4.5   Admixtures

ASTM C494/C494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture or KS F 2560. Do not use calcium chloride admixtures.

2.4.5.1   Air-Entraining

ASTM C260/C260M or KS F 2560.

2.4.5.2   High Range Water Reducer (HRWR) (Superplasticizers)

ASTM C494/C494M, Type F and Type G (HRWR retarding admixture) or KS F 2560 and ASTM C1017/C1017M.

2.4.5.3   Pozzolan

Provide fly ash or other pozzolans used as admixtures that conform to ASTM C618 or KS L 5508.

2.4.6   Vapor Retarder and Vapor Barrier

ASTM E1745 Class A polyethylene sheeting, minimum 0.25 mm (10 mil) thickness or other equivalent material.

Waterproof Paper. Kraft paper, glass reinforcing fibers and layers of polyethylene laminated under heat and pressure to form a single layer meeting the requirements of FS UU-B-790, Type I, Grade A, Style 4; or waterproof paper, regular, conforming to ASTM C171 or KS M 3354, consisting of two sheets of kraft paper cemented together with bituminous material in which are embedded cords or strands of fiber running in both directions not more than 30 mm (1 1/4 inch) apart.

Consider plastic vapor retarders and adhesives with a high recycled content, low toxicity low VOC (Volatile Organic Compounds) levels.

2.4.7 Materials for Curing Concrete

Consider the use of water based or vegetable or soy based curing agents in lieu of petroleum based products. Consider agents that are not toxic and emit low or no Volatile Organic Compounds (VOC). Consider the use of admixtures that offer high performance to increase durability of the finish product but also have low toxicity and are made from bio-based materials such as soy, and emit low levels of Volatile Organic Compounds (VOC).

2.4.7.1 Impervious Sheeting

ASTM C171 or KS M 3354; waterproof paper, clear or white polyethylene sheeting, or polyethylene-coated burlap.

2.4.7.2 Pervious Sheeting

AASHTO M 182.

2.4.7.3 Liquid Membrane-Forming Compound

ASTM C309, white-pigmented, Type 2, Class B, or KS F 2540.

2.4.8 Liquid Chemical Sealer-Hardener Compound

Provide surface treatments containing certain chemicals, including sodium silicate and the fluosilicates of magnesium and zinc. Provide compound that does not reduce the adhesion of resilient flooring, tile, paint, roofing, waterproofing, or other material applied to concrete.

2.4.9 Expansion/Contraction Joint Filler

ASTM D1751, ASTM D1752, or KS F 2538 cork or 100 percent post-consumer paper meeting ASTM D1752 (subparagraphs 5.1 to 5.4). Material must be 13 mm (1/2 inch) thick, unless otherwise indicated.

2.4.9.1 Preformed Joint Filler Strips

Provide nonextruding and resilient bituminous type filler strips conforming to ASTM D1751 or KS F 2538.

2.4.10 Joint Sealants

2.4.10.1 Horizontal Surfaces, 3 Percent Slope, Maximum

ASTM D6690 or ASTM C920, Type M, Class 25, Use T. ASTM D7116 for surfaces subjected to jet fuel.

2.4.10.2 Vertical Surfaces Greater Than 3 Percent Slope

ASTM C920, Type M, Grade NS, Class 25, Use T.

2.4.10.3 Waterstops

Provide waterstops made of rubber and that conform to ASTM D1752 or provide waterstops made of polyvinylchloride (PVC) and that conform to

ASTM C990M (ASTM C990) or ASTM D2628.

2.4.10.4 Joint Sealant Compound

Provide cold-applied, two-component, elastomeric polymer type compound conforming to FS SS-S-200.

2.4.11 Epoxy Bonding Compound

ASTM C881/C881M. Provide Type I for bonding hardened concrete to hardened concrete; Type II for bonding freshly mixed concrete to hardened concrete; and Type III as a binder in epoxy mortar or concrete, or for use in bonding skid-resistant materials to hardened concrete. Provide Grade 1 or 2 for horizontal surfaces and Grade 3 for vertical surfaces. Provide Class A if placement temperature is below 4 degrees C (40 degrees F); Class B if placement temperature is between 4 and 16 degrees C (40 and 60 degrees F); or Class C if placement temperature is above 16 degrees C (60 degrees F).

2.5 REINFORCEMENT

Galvanize bars, fabrics, connectors, and chairs, unless otherwise indicated.

2.5.1 Reinforcing Bars

ACI/MCP-2 unless otherwise specified. ASTM A615/A615M and AASHTO M 322M/M 322 with the bars marked A, S, W, Grade 420 (60), unless otherwise indicated; or ASTM A996/A996M with the bars marked R, Grade 350 (50), or marked A, Grade 300 (40), unless otherwise indicated. Galvanized, ASTM A123/A123M. Zinc-coated (galvanized) bars, ASTM A767/A767M and ASTM A780/A780M. Epoxy-coated reinforcing steel bars, ASTM A775/A775M. Epoxy-coated prefabricated steel reinforcing bars, ASTM A934/A934M.

2.5.1.1 Galvanized Reinforcing Bars

Provide galvanized reinforcing bars that conform to ASTM A767/A767M, Class II with galvanizing before fabrication.

2.5.1.2 Weldable Reinforcing Bars

Provide weldable reinforcing bars that conform to ASTM A706/A706M and ASTM A615/A615M and Supplement S1, Grade 60, except that the maximum carbon content must be 0.55 percent.

2.5.1.3 Epoxy-Coated Reinforcing Bars

Provide epoxy-coated reinforcing bars that conform to ASTM A775/A775M, Grade 40 or Grade 60.

2.5.2 Mechanical Reinforcing Bar Connectors

ACI/MCP-2. Provide 125 percent minimum yield strength of the reinforcement bar.

2.5.3 Wire

ASTM A82/A82M or ASTM A496/A496M.

2.5.3.1 Welded Wire Fabric

ASTM A185/A185M or ASTM A497/A497M. Provide flat sheets of welded wire fabric for slabs and toppings.

2.5.3.2 Steel Wire

Wire must conform to ASTM A82/A82M.

2.5.4 Reinforcing Bar Supports

Provide bar ties and supports of coated or non corrodible material.

2.5.5 Fiber-Reinforced Concrete

If indicated on contract drawings, provide fiber reinforced concrete in accordance with ASTM C1116/C1116M Type III, synthetic fiber reinforced concrete, and as follows. Synthetic reinforcing fibers must be 100 percent virgin monofilament polypropylene fibers. Provide fibers that have a specific gravity of 0.9, a minimum tensile strength of 480 MPa (70 ksi), graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement. Use a minimum of 0.9 kg of fibers per cubic meter (1.5 pounds of fibers per cubic yard) of concrete. Add fibers at the batch plant. Toughness indices must meet requirements for performance level I. Provide the services of a qualified technical representative to instruct the concrete supplier in proper batching and mixing of materials to be provided.

2.5.6 Dowels for Load Transfer in Floors

Provide dowels for load transfer in floors of the type, design, weight, and dimensions indicated. Provide dowel bars that are plain-billet steel conforming to ASTM A615/A615M, Grade 40. Provide dowel pipe that is steel conforming to ASTM A53/A53M.

2.6 BONDING MATERIALS

2.6.1 Concrete Bonding Agent

Provide aqueous-phase, film-forming, nonoxidizing, freeze and thaw-resistant compound agent suitable for brush or spray application conforming to ASTM C932.

2.6.2 Epoxy-Resin Adhesive Binder

Provide two-component, epoxy-polysulfide polymer type binder with an amine-type curing-agent conforming to ASTM C881/C881M.

2.7 FLOOR FINISH MATERIALS

2.7.1 Liquid Chemical Floor Hardener

Hardener must be a colorless aqueous solution containing a blend of magnesium fluorosilicate and zinc fluorosilicate combined with a wetting agent. Solution must contain not less than 240 grams per liter (1/2 pound per gallon) of fluorosilicates . An approved proprietary chemical hardener may be used provided hardener is delivered ready for use in manufacturer's original containers.

2.7.2 Abrasive Aggregate for Nonslip Aggregate Finish

Aggregate must be packaged, factory-graded fused aluminum oxide grits, or it may be crushed emery containing not less than 40-percent aluminum oxide and not less than 25-percent ferric oxide. Aggregate must be rust proof and nonglazing and must be unaffected by freezing, moisture, and cleaning materials.

2.7.3 Dry Materials for Colored Wear-Resistant Finish

Provide materials that are packaged, dry, and a combination of materials formulated for producing colored and wear-resistant monolithic surface treatments; they must include portland cement, graded-quartz aggregate, coloring pigments, and dispersing agents. Provide coloring pigments that are finely ground, nonfacing mineral oxides prepared especially for the purpose and interground with the cement.

2.7.4 Aggregate for Heavy-Duty Floor Topping

Provide emery (or may be traprock or traprock-screenings) fine aggregates, as specified.

Provide emery that is packaged, factory-graded, crushed natural emery ore containing not less than 35-percent aluminum oxide and not less than 24-percent ferric oxide. Provide aggregate that is cubical or polyhedral in form and does not change its physical or chemical nature in the presence of moisture. Grade aggregate to a fineness modulus of 3.9 to 4.0, with 100 percent passing 9.5 mm (3/8-inch) sieve and not less than 95 percent retained on 150 micrometer (No. 100) sieve. Deliver emery in moisture-resistant bags.

Provide traprock that is packaged, crushed, natural, fine- to medium-grained igneous rock such as diabase, basalt, or black granite. Uniformly grade coarse aggregate with 100 percent passing 12.5 mm (1/2-inch) sieve, 30 to 50 percent passing 9.5 mm (3/8-inch) sieve, 0 to 15 percent passing 4.75 mm (No. 4) sieve, and 0 to 5 percent passing 2.36 mm (No. 8) sieve.

Provide fine aggregate using traprock that conforms to ASTM C33/C33M, except gradation. Grade fine aggregate within the following limits:

SIEVE	PERCENT PASSING
9.5 mm (3/8 in.)	100
4.75 mm (No. 4)	95 to 100
2.36 mm (No. 8)	65 to 80
1.18 mm (No. 16)	45 to 65
600 micrometer (No. 30)	25 to 45
300 micrometer (No. 50)	5 to 15

SIEVE	PERCENT PASSING
150 micrometer (No. 100)	0 to 5

Deliver traprock coarse aggregate and fine aggregate in moisture-resistant bags.

2.8 CLASSIFICATION AND QUALITY OF CONCRETE

Provide certificates that contain project name and number, date, name of Contractor, name of concrete testing service, source of concrete aggregates, material manufacturer, brand name of manufactured materials, material name, values as specified for each material, and test results.

2.8.1 Concrete Classes and Usage

Provide concrete classes, compressive strength, requirements for air entrainment, and usage as follows:

CONCRETE CLASS	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER MEGA pascal (POUNDS PER SQ. IN.)	REQUIREMENT FOR AIR ENTRAINMENT	USAGE
3a	20 (3000)	Air-entrained	For foundation concrete work exposed to freezing and thawing or subjected to hydraulic pressure, such as foundation walls, grade beams, pits, tunnels. For exterior concrete slabs, such as steps, platforms, walks
3N	20 (3000)	Nonair-entrained	For foundation concrete work not exposed to freezing and thawing or subjected to hydraulic pressure, such as footings, pile caps, foundation mats. For interior slabs on ground to be covered with resilient flooring
4A	27.6 (4000)	Air-entrained	For structural concrete work exposed to freezing and thawing, unless otherwise indicated or specified, such as exterior columns and spandrels

CONCRETE CLASS	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER MEGA pascal (POUNDS PER SQ. IN.)	REQUIREMENT FOR AIR ENTRAINMENT	USAGE
4N	27.6 (4000)	Nonair-entrained	For structural concrete work not exposed to freezing and thawing such as interior columns, beams, supported slabs and other structural members for interior slabs on ground subjected to foot traffic
2.5A	17.2 (2500)	Air-entrained	For concrete not reinforced and not exposed to freezing and thawing
2.5N	17.2 (2500)	Nonair-entrained	For concrete not reinforced and not exposed to freezing and thawing
5A	34.5 (5000)	Air-entrained	For structural concrete work as indicated
5N	34.5 (5000)	Nonair-entrained	For structural concrete work as indicated

2.8.2 Limits for Concrete Proportions

Provide limits for maximum water/cement ratio and minimum cement content for each concrete class as follows:

CONCRETE CLASS	MAX. WATER/CEMENT RATIO BY WEIGHT	MIN. CEMENT FOR 75 TO 100 MM (3- TO 4-INCH) SLUMP, (NO. OF 43 KILOGRAM (94-POUND) SACKS) PER CU. METER (CU. YD.)
2.5A	0.58	4.75
2.5N	0.62	4.75
3A	0.50	5.25
3N	0.54	5.25
4A	0.46	6.0
4N	0.48	6.0

CONCRETE CLASS	MAX. WATER/CEMENT RATIO BY WEIGHT	MIN. CEMENT FOR 75 TO 100 MM (3- TO 4-INCH) SLUMP, (NO. OF 43 KILOGRAM (94-POUND) SACKS) PER CU. METER (CU. YD.)
5A	0.41	6.5
5N	0.44	6.5
* Weight of water to weight of cement in pounds in one cubic yard of concrete.		

2.8.3 Maximum Size of Aggregate

Size of aggregate, designated by the sieve size on which maximum amount of retained coarse aggregate is 5 to 10 percent by weight, must be as follows:

MAXIMUM SIZE OF AGGREGATE	ASTM C33/C33M SIZE NUMBER	TYPE OF CONSTRUCTION
50.8 mm (2 inches)	357	Nonreinforced footings and other flat work having a depth of not less than 150 mm)6 inches), and nonreinforced walls and other formed sections having a dimension between forms of not less than 250 mm 10 inches)
38.1 mm (1-1/2 inches)	467	Monolithic slabs on ground, concrete fill, and other flatwork having a depth of not less than 125 mm (5 inches) and a clear distance between reinforcing bars of not less than 50 mm (2 inches)

19.1 mm (3/4 inch)	67	Reinforced walls, columns, girders, beams, and other formed sections having a dimension between forms of not less than 150 mm (6 inches) and clear distance between reinforcing bars or reinforcing bar and face of form of not less than 25 mm 1 inch
19.1 mm (3/4 inch)	67	Monolithic concrete slabs and other flatwork having a depth of not less than 65 mm (2-1/2 inches) and a clear distance between reinforcing bars of not less than 25 mm (1 inch)
12.7 mm (1/2 inch)	7	Concrete joist construction, beams, reinforced walls, and other formed work having a clear distance between reinforcing bars and face of form of less than 25 mm (1 inch)
9.5mm (3/8 inch)	8	Nonreinforced slabs and other flatwork having a depth of less than 65 mm (2-1/2 inches)

Maximum size of aggregate may be that required for most critical type of construction using that concrete class.

Specify gradation of aggregates for separate floor topping.

2.8.4 Slump

Provide slump for concrete at time and in location of placement as follows:

TYPE OF CONSTRUCTION	SLUMP
Footings, nonreinforced walls	Not less than 25 millimeter (1 inch) nor more than 75 millimeter 3 inches)
Columns, beams, reinforced walls, monolithic slabs	Not less than 25 millimeter (1 inch) nor more than 100 millimeter (4 inches)
Ramps and other sloping surfaces	0 nor more than 75 millimeter (3 inches)

2.8.5 Total Air Content

Air content of exposed concrete and interior concrete must be in accordance with ASTM C260/C260M or KS F 2560 and as follows:

LIMITS OF CONCRETE EXPOSURE	REQUIREMENT FOR AIR ENTRAINMENT	MAXIMUM SIZE OF AGGREGATE	TOTAL AIR CONTENT BY VOLUME
Exposed to freezing and thawing or subjected to hydraulic pressure	Air-entrained	38.1 or 69.9 mm (1-1/2 or 2 inches)	4 to 6 percent
		19 mm (3/4 inch)	5 to 7 percent
		12.7 or 9.5 mm (1/2 or 3/8 inch)	6 to 8.5 percent

Provide concrete exposed to freezing and thawing or subjected to hydraulic pressure that is air-entrained by addition of approved air-entraining admixture to concrete mix.

2.9 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Do not begin installation until substrates have been properly constructed; verify that substrates are plumb and true.

If substrate preparation is the responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before processing.

Check field dimensions before beginning installation. If dimensions vary too much from design dimensions for proper installation, notify Architect/Engineer and wait for instructions before beginning installation.

3.2 PREPARATION

Determine quantity of concrete needed and minimize the production of excess concrete. Designate locations or uses for potential excess concrete before the concrete is poured.

3.2.1 General

Surfaces against which concrete is to be placed must be free of debris, loose material, standing water, snow, ice, and other deleterious substances before start of concrete placing.

Remove standing water without washing over freshly deposited concrete. Divert flow of water through side drains provided for such purpose.

3.2.2 Subgrade Under Foundations and Footings

When subgrade material is semiporous and dry, sprinkle subgrade surface with water as required to eliminate suction at the time concrete is deposited. When subgrade material is porous, seal subgrade surface by covering surface with specified vapor retarder; this may also be used over semiporous, dry subgrade material instead of water sprinkling.

3.2.3 Subgrade Under Slabs on Ground

Before construction of slabs on ground, have underground work on pipes and conduits completed and approved.

Previously constructed subgrade or fill must be cleaned of foreign materials and inspected by the Contractor for adequate compaction and surface tolerances as specified.

Actual density of top 300 mm (12 inches) of subgrade soil material-in-place must not be less than the following percentages of maximum density of same soil material compacted at optimum moisture content in accordance with ASTM D1557.

SOIL MATERIAL	PERCENT MAXIMUM DENSITY
Capillary water barrier	100
Cohesionless soil material	100
Cohesive soil material	95

Finish surface of capillary water barrier under interior slabs on ground must not show deviation in excess of 6.4 mm (1/4 inch) when tested with a 3000 mm (10-foot) straightedge parallel with and at right angles to building lines.

Finished surface of subgrade or fill under exterior slabs on ground must not be more than 6.10 mm (0.02-foot) above or 30.50 mm (0.10-foot) below elevation indicated.

Prepare subgrade or fill surface under exterior slabs on ground as specified for subgrade under foundations and footings.

3.2.4 Formwork

Complete and approve formwork. Remove debris and foreign material from interior of forms before start of concrete placing.

3.2.5 Edge Forms and Screed Strips for Slabs

Set edge forms or bulkheads and intermediate screed strips for slabs to obtain indicated elevations and contours in finished slab surface and must be strong enough to support vibrating bridge screeds or roller pipe screeds if nature of specified slab finish requires use of such equipment. Align concrete surface to elevation of screed strips by use of strike-off templates or approved compacting-type screeds.

3.2.6 Reinforcement and Other Embedded Items

Secure reinforcement, joint materials, and other embedded materials in position, inspected, and approved before start of concrete placing.

3.3 FORMS

ACI/MCP-2. Provide forms, shoring, and scaffolding for concrete placement. Set forms mortar-tight and true to line and grade. Chamfer above grade exposed joints, edges, and external corners of concrete 20 mm (0.75 inch) unless otherwise indicated. Provide formwork with clean-out openings to permit inspection and removal of debris. Forms submerged in water must be watertight.

3.3.1 General

Construct forms to conform, within the tolerances specified, to shapes dimensions, lines, elevations, and positions of cast-in-place concrete members as indicated. Forms must be supported, braced, and maintained sufficiently rigid to prevent deformation under load.

3.3.2 Design and Construction of Formwork

Provide formwork design and construction that conforms to ACI/MCP-2, Chapter 4.

Provide forms that are tight to prevent leakage of cement paste during concrete placing.

Support form facing materials by structural members spaced close to prevent deflection of form facing material. Fit forms placed in successive units for continuous surfaces to accurate alignment to ensure a smooth completed surface within the tolerances specified. Where necessary to maintain the tolerances specified, such as long spans where immediate supports are not possible, camber formwork for anticipated deflections in formwork due to weight and pressure of fresh concrete and to construction loads.

Chamfer exposed joints, edges, and external corners a minimum of 19 mm

(3/4 inch) by moldings placed in corners of column, beam, and wall forms.

Provide shores and struts with a positive means of adjustment capable of taking up formwork settlement during concrete placing operations. Obtain adjustment with wedges or jacks or a combination thereof. When adequate foundations for shores and struts cannot be secured, provide trussed supports.

Provide temporary openings in wall forms, column forms, and at other points where necessary to permit inspection and to facilitate cleaning.

Provide forms that are readily removable without impact, shock, or damage to concrete.

3.3.3 Coating

Before concrete placement, coat the contact surfaces of forms with a nonstaining mineral oil, nonstaining form coating compound, or two coats of nitrocellulose lacquer. Do not use mineral oil on forms for surfaces to which adhesive, paint, or other finish material is to be applied.

3.3.4 Reshoring

Reshore concrete elements where forms are removed prior to the specified time period. Do not permit elements to deflect or accept loads during form stripping or reshoring. Forms on columns, walls, or other load-bearing members may be stripped after 2 days if loads are not applied to the members. After forms are removed, reshore slabs and beams over 3000 mm (10 feet) in span and cantilevers over 1200 mm (4 feet) for the remainder of the specified time period in accordance with paragraph entitled "Removal of Forms." Perform reshoring operations to prevent subjecting concrete members to overloads, eccentric loading, or reverse bending. Provide reshoring elements with the same load-carrying capabilities as original shoring and spaced similar to original shoring. Firmly secure and brace reshoring elements to provide solid bearing and support.

3.3.5 Reuse

Reuse forms providing the structural integrity of concrete and the aesthetics of exposed concrete are not compromised.

3.3.6 Forms for Standard Rough Form Finish

Give rough form finish concrete formed surfaces that are to be concealed by other construction, unless otherwise specified.

Form facing material for standard rough form finish must be the specified concrete form plywood or other approved form facing material that produces concrete surfaces equivalent in smoothness and appearance to that produced by new concrete form plywood panels.

For concrete surfaces exposed only to the ground, undressed, square-edge, 25 mm (1-inch) nominal thickness lumber may be used. Provide horizontal joints that are level and vertical joints that are plumb.

3.3.7 Forms for Standard Smooth Form Finish

Give smooth form finish concrete formed surfaces that are to be exposed to view or that are to be covered with coating material applied directly to concrete or with covering material bonded to concrete, such as waterproofing, dampproofing, painting, or other similar coating system.

Form facing material for standard smooth finish must be the specified overlaid concrete form plywood or other approved form facing material that is nonreactive with concrete and that produce concrete surfaces equivalent in smoothness and appearance to that produced by new overlaid concrete form plywood panels.

Maximum deflection of form facing material between supports and maximum deflection of form supports such as studs and wales must not exceed 0.0025 times the span.

Provide arrangement of form facing sheets that are orderly and symmetrical, and sheets that are in sizes as large as practical.

Arrange panels to make a symmetrical pattern of joints. Horizontal and vertical joints must be solidly backed and butted tight to prevent leakage and fins.

3.3.8 Form Ties

Provide ties that are factory fabricated metal, adjustable in length, removable or snap-off type that do allow form deflection or do not spall concrete upon removal. Portion of form ties remaining within concrete after removal of exterior parts must be at least 38 mm (1-1/2 inches) back from concrete surface. Provide form ties that are free of devices that leave a hole larger than 22 mm (7/8 inch) or less than 13 mm (1/2 inch) in diameter in concrete surface. Form ties fabricated at the project site or wire ties of any type are not acceptable.

3.3.9 Forms for Concrete Pan Joist Construction

Provide forms that are well-fitting, undamaged, factory-fabricated pan form units for concrete joist construction as indicated.

Form units complete with covers and end closures as required for the installation must be one of the following:

Steel, 1.6 mm (16-gage), free from irregularities, dents, sag, and rust

Hardboard conforming to ACI/MCP-3 and ACI/MCP-4

Glass-fiber-reinforced plastic, molded under pressure, with matched dies, 2.8 mm (0.11-inch) maximum wall thickness

Asphalt-impregnated, corrugated material treated for moisture resistance with factory-applied polyethylene coating, with top and side cover joints taped where concrete is exposed.

Provide tight forms for concrete pan joist construction to prevent cement paste loss during concrete placing and to form a true, clean, smooth surface, free of honeycomb and rough exposed-aggregate areas. Take precautions, including blocking of adjoining pan units, to avoid lateral deflection of formwork during compaction of concrete.3.3.10 Tolerances for Form Construction

Construct formwork to ensure that after removal of forms and prior to patching and finishing of formed surfaces, provide concrete surfaces in accordance with tolerances specified in ACI/MCP-1 and ACI/MCP-2.

3.3.11 Removal of Forms and Supports

After placing concrete, forms must remain in place for the time periods specified in ACI/MCP-4. Do not remove forms and shores (except those used for slabs on grade and slip forms) until the client determines that the concrete has gained sufficient strength to support its weight and superimposed loads. Base such determination on compliance with one of the following:

a. The plans and specifications stipulate conditions for removal of forms and shores, and such conditions have been followed, or

b. The concrete has been properly tested with an appropriate ASTM standard test method designed to indicate the concrete compressive strength, and the test results indicate that the concrete has gained sufficient strength to support its weight and superimposed loads.

Prevent concrete damage during form removal. Clean all forms immediately after removal.

3.3.11.1 Special Requirements for Reduced Time Period

Forms may be removed earlier than specified if ASTM C39/C39M or KS F 2405 test results of field-cured samples from a representative portion of the structure indicate that the concrete has reached a minimum of 85 percent of the design strength.

3.4 WATERSTOP SPLICES

Fusion weld in the field.

3.5 FORMED SURFACES

3.5.1 Preparation of Form Surfaces

Coat contact surfaces of forms with form-coating compound before reinforcement is placed. Provide a commercial formulation form-coating compound that does not bond with, stain, nor adversely affect concrete surfaces and impair subsequent treatment of concrete surfaces that entails bonding or adhesion nor impede wetting of surfaces to be cured with water or curing compounds. Do not allow excess form-coating compound to stand in puddles in the forms nor to come in contact with concrete against which fresh concrete is placed. Make thinning of form-coating compound with thinning agent of the type, in the amount, and under the conditions recommended by form-coating compound manufacturer's printed or written directions.

3.5.2 Tolerances

ACI/MCP-4 and as indicated.

3.5.3 As-Cast Form

Provide form facing material producing a smooth, hard, uniform texture on the concrete. Arrange facing material in an orderly and symmetrical manner and keep seams to a practical minimum. Support forms as necessary to meet required tolerances. Do not use material with raised grain, torn surfaces, worn edges, patches, dents, or other defects which can impair the texture of the concrete surface.

3.6 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

ACI/MCP-2. Provide bars, wire fabric, wire ties, supports, and other devices necessary to install and secure reinforcement. Reinforcement must not have rust, scale, oil, grease, clay, or foreign substances that would reduce the bond. Rusting of reinforcement is a basis of rejection if the effective cross-sectional area or the nominal weight per unit length has been reduced. Remove loose rust prior to placing steel. Tack welding is prohibited.

3.6.1 General

Provide details of reinforcement that are in accordance with ACI/MCP-3 and ACI/MCP-4 and as specified.

3.6.2 Vapor Retarder and Vapor Barrier

Provide beneath the on-grade concrete floor slab. Use the greatest widths and lengths practicable to eliminate joints wherever possible. Lap joints a minimum of 300 mm (12 inches) and tape or cement joints. Remove torn, punctured, or damaged vapor retarder and vapor barrier material and provide with new vapor retarder and vapor barrier prior to placing concrete. Concrete placement must not damage vapor retarder and vapor barrier material.

3.6.3 Reinforcement Supports

Place reinforcement and secure with galvanized or non corrodible chairs, spacers, or metal hangers. For supporting reinforcement on the ground, use concrete or other non corrodible material, having a compressive strength equal to or greater than the concrete being placed.

ASTM A934/A934M. ASTM A775/A775M. Rest epoxy-coated reinforcing bars supported from formwork on coated wire bar supports, or on bar supports made of dielectric material or other acceptable material. Coat wire bar supports with dielectric material, compatible with concrete, for a minimum distance of 50 mm (2 inches) from the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars must be epoxy coated. Spreader bars, where used, must be epoxy coated. Make proprietary combination bar clips and spreaders used in construction with epoxy-coated reinforcing bars corrosion resistant or coated with dielectric material. Tie epoxy-coated bars with plastic-coated tie wire; or other materials acceptable to the Contracting Officer.

3.6.4 Epoxy Coated Reinforcing

Epoxy Coated Reinforcing must meet the requirements of ASTM A934/A934M including Appendix X2, or ASTM A775/A775M including Appendix X1, "Guidelines for Job Site Practices" except as otherwise specified herein.

3.6.4.1 Epoxy Coated Reinforcing Steel Placement and Coating Repair

Carefully handle and install bars to minimize job site patching. Use the same precautions as described in paragraph for reinforcement delivery, handling, and storage when placing coated reinforcement. Do not drag bars over other bars or over abrasive surfaces. Keep bar free of dirt and grit. When possible, assemble reinforcement as tied cages prior to final placement into the forms. Support assembled cages on padded supports. It is not expected that coated bars, when in final position ready for concrete placement, are completely free of damaged areas; however, excessive nicks and scrapes which expose steel is cause for rejection. Criteria for defects which require repair and for those that do not require repair are as indicated. Inspect for defects and provide required repairs prior to assembly. After assembly, reinspect and provide final repairs.

a. Immediately prior to application of the patching material, manually remove any rust and debonded coating from the reinforcement by suitable techniques employing devices such as wire brushes and emery paper. Exercise cars during this surface preparation so that the damaged areas are not enlarged more than necessary to accomplish the repair. Clean damaged areas of dirt, debris, oil, and similar materials prior to application of the patching material.

b. Do repair and patching in accordance with the patching material manufacturer's recommendations. These recommendations, including cure times, must be available at the job site at all times.

c. Allow adequate time for the patching materials to cure in accordance with the manufacturer's recommendation prior to concrete placement.

3.6.5 Splicing

As indicated. For splices not indicated ACI/MCP-2. Do not splice at points of maximum stress. Overlap welded wire fabric the spacing of the cross wires, plus 50 mm (2 inches). Repair the cut ends of hot-dipped galvanized reinforcement steel to completely coat exposed steel, ASTM A780/A780M.

3.6.6 Future Bonding

Plug exposed, threaded, mechanical reinforcement bar connectors with a greased bolt. Provide bolt threads that match the connector. Countersink the connector in the concrete. Caulk the depression after the bolt is installed.

3.6.7 Cover

ACI/MCP-2 for minimum coverage, unless otherwise indicated.

3.6.8 Setting Miscellaneous Material

Place and secure anchors and bolts, pipe sleeves, conduits, and other such items in position before concrete placement. Plumb anchor bolts and check location and elevation. Temporarily fill voids in sleeves with readily removable material to prevent the entry of concrete.

3.6.9 Construction Joints

Locate joints to least impair strength. Continue reinforcement across joints unless otherwise indicated.

3.6.10 Expansion Joints and Contraction Joints

Provide expansion joint at edges of interior floor slabs on grade abutting vertical surfaces, and as indicated. Make expansion joints 13 mm (1/2 inch) wide unless indicated otherwise. Fill expansion joints not exposed to weather with preformed joint filler material. Completely fill joints exposed to weather with joint filler material and joint sealant. Do not extend reinforcement or other embedded metal items bonded to the concrete through any expansion joint unless an expansion sleeve is used. Provide contraction joints, either formed or saw cut or cut with a jointing tool, to the indicated depth after the surface has been finished. Complete saw joints within 4 to 12 hours after concrete placement. Protect joints from intrusion of foreign matter.

3.6.11 Fabrication

Submit mill certificates for Steel Bar according to the paragraph entitled, "Fabrication," of this section.

Shop fabricate reinforcing bars to conform to shapes and dimensions indicated for reinforcement, and as follows:

Provide fabrication tolerances that are in accordance with ACI/MCP-1, ACI/MCP-2 and ACI/MCP-3.

Provide hooks and bends that are in accordance with ACI/MCP-3 and ACI/MCP-4.

Reinforcement must be bent cold to shapes as indicated. Bending must be done in the shop. Rebending of a reinforcing bar that has been bent incorrectly is not be permitted. Bending must be in accordance with standard approved practice and by approved machine methods.

Tolerance on nominally square-cut, reinforcing bar ends must be in accordance with ACI/MCP-3.

Deliver reinforcing bars bundled, tagged, and marked. Tags must be metal with bar size, length, mark, and other information pressed in by machine. Marks must correspond with those used on the placing drawings.

Do not use reinforcement that has any of the following defects:

a. Bar lengths, depths, and bends beyond specified fabrication tolerances

b. Bends or kinks not indicated on drawings or approved shop drawings

c. Bars with reduced cross-section due to rusting or other cause

Replace defective reinforcement with new reinforcement having required shape, form, and cross-section area.

3.6.12 Placing Reinforcement

Place reinforcement in accordance with ACI/MCP-3 and ACI/MCP-4.

For slabs on grade (over earth or over capillary water barrier) and for footing reinforcement, support bars or welded wire fabric on precast concrete blocks, spaced at intervals required by size of reinforcement, to keep reinforcement the minimum height specified above the underside of slab or footing.

For slabs other than on grade, supports for which any portion is less than 25 mm (1 inch) from concrete surfaces that are exposed to view or to be painted must be of precast concrete units, plastic-coated steel, or stainless steel protected bar supports. Precast concrete units must be wedge shaped, not larger than 90 by 90 mm, (3-1/2 by 3-1/2 inches), and of thickness equal to that indicated for concrete protection of reinforcement. Provide precast units that have cast-in galvanized tie wire hooked for anchorage and blend with concrete surfaces after finishing is completed.

Contractor must cooperate with other trades in setting of anchor bolts, inserts, and other embedded items. Where conflicts occur between locating reinforcing and embedded items, the Contractor must notify the Contracting Officer so that conflicts may be reconciled before placing concrete. Anchors and embedded items must be positioned and supported with appropriate accessories.

Handle epoxy-coated reinforcing bars carefully to prevent damage to the coating. Use plastic-coated tie wire and supports of a type to prevent damage to the reinforcing bars.

Provide reinforcement that is supported and secured together to prevent displacement by construction loads or by placing of wet concrete, and as follows:

Provide supports for reinforcing bars that are sufficient in number and sufficiently heavy to carry the reinforcement they support, and in accordance with ACI/MCP-3, ACI/MCP-4 and CRSI 10MSP. Do not use supports to support runways for concrete conveying equipment and similar construction loads.

Equip supports on ground and similar surfaces with sand-plates.

Support welded wire fabric as required for reinforcing bars.

Secure reinforcements to supports by means of tie wire. Wire must be black, soft iron wire, not less than 1.6 mm v16 gage).

With the exception of temperature reinforcement, tied to main steel approximately 600 mm (24 inches) on center, reinforcement must be accurately placed, securely tied at intersections with 1.3 mm (18-gage) annealed wire, and held in position during placing of concrete by spacers, chairs, or other approved supports. Point wire-tie ends away from the form. Unless otherwise indicated, numbers, type, and spacing of supports must conform to ACI/MCP-3.

Bending of reinforcing bars partially embedded in concrete is permitted only as specified in ACI/MCP-3 and ACI/MCP-4.

3.6.13 Spacing of Reinforcing Bars

Spacing must be as indicated. If not indicated, spacing must be in accordance with the ACI/MCP-3 and ACI/MCP-4.

Reinforcing bars may be relocated to avoid interference with other reinforcement, or with conduit, pipe, or other embedded items. If any reinforcing bar is moved a distance exceeding one bar diameter or specified placing tolerance, resulting rearrangement of reinforcement is subject to approval.

3.6.14 Concrete Protection for Reinforcement

Concrete protection must be in accordance with the ACI/MCP-3 and ACI/MCP-4.

3.6.15 Welding

Welding must be in accordance with AWS D1.4/D1.4M.

3.7 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE

ASTM C94/C94M or KS F 4009, and ACI/MCP-2, except as modified herein. Batching equipment must be such that the concrete ingredients are consistently measured within the following tolerances: 1 percent for cement and water, 2 percent for aggregate, and 3 percent for admixtures. Furnish mandatory batch ticket information for each load of ready mix concrete.

3.7.1 Measuring

Make measurements at intervals as specified in paragraphs entitled "Sampling" and "Testing."

3.7.2 Mixing

ASTM C94/C94M or KS F 4009, and ACI/MCP-2. Machine mix concrete. Begin mixing within 30 minutes after the cement has been added to the aggregates. Place concrete within 90 minutes of either addition of mixing water to cement and aggregates or addition of cement to aggregates if the air temperature is less than 29 degrees C (84 degrees F). Reduce mixing time and place concrete within 60 minutes if the air temperature is greater than 29 degrees C (84 degrees F) except as follows: if set retarding admixture is used and slump requirements can be met, limit for placing concrete may remain at 90 minutes. Additional water may be added, provided that both the specified maximum slump and water-cement ratio are not exceeded. When additional water is added, an additional 30 revolutions of the mixer at mixing speed is required. If the entrained air content falls below the specified limit, add a sufficient quantity of admixture to bring the entrained air content within the specified limits. Dissolve admixtures in the mixing water and mix in the drum to uniformly distribute the admixture throughout the batch.

3.7.3 Transporting

Transport concrete from the mixer to the forms as rapidly as practicable. Prevent segregation or loss of ingredients. Clean transporting equipment thoroughly before each batch. Do not use aluminum pipe or chutes. Remove concrete which has segregated in transporting and dispose of as directed.

3.8 PLACING CONCRETE

Place concrete as soon as practicable after the forms and the reinforcement have been inspected and approved. Do not place concrete when weather conditions prevent proper placement and consolidation; in uncovered areas during periods of precipitation; or in standing water. Prior to placing concrete, remove dirt, construction debris, water, snow, and ice from within the forms. Deposit concrete as close as practicable to the final position in the forms. Do not exceed a free vertical drop of 1 m (3 feet) from the point of discharge. Place concrete in one continuous operation from one end of the structure towards the other. Position grade stakes on 3 m (10 foot) centers maximum in each direction when pouring interior slabs and on 6 m (20 foot) centers maximum for exterior slabs.

3.8.1 General Placing Requirements

Deposit concrete continuously or in layers of such thickness that no concrete is placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within the section. If a section cannot be placed continuously, provide construction joints as specified. Perform concrete placing at such a rate that concrete which is being integrated with fresh concrete is still plastic. Deposit concrete as nearly as practical in its final position to avoid segregation due to rehandling or flowing. Do not subject concrete to procedures which cause segregation.

Concrete to receive other construction must be screeded to proper level to avoid excessive skimming or grouting.

Do not use concrete which becomes nonplastic and unworkable or does not meet quality control limits as specified or has been contaminated by foreign materials. Use of retempered concrete is permitted. Remove rejected concrete from the site.

3.8.2 Footing Placement

Concrete for footings may be placed in excavations without forms upon inspection and approval by the Contracting Officer. Excavation width must be a minimum of 100 mm (4 inches) greater than indicated.

3.8.3 Vibration

ACI/MCP-2. Furnish a spare, working, vibrator on the job site whenever concrete is placed. Consolidate concrete slabs greater than 100 mm (4 inches) in depth with high frequency mechanical vibrating equipment supplemented by hand spading and tamping. Consolidate concrete slabs 100 mm (4 inches) or less in depth by wood tampers, spading, and settling with a heavy leveling straightedge. Operate internal vibrators with vibratory element submerged in the concrete, with a minimum frequency of not less than 6000 impulses per minute when submerged. Do not use vibrators to transport the concrete in the forms. Penetrate the previously placed lift with the vibrator when more than one lift is required. Use external vibrators on the exterior surface of the forms when internal vibrators do not provide adequate consolidation of the concrete.

3.8.4 Application of Epoxy Bonding Compound

Apply a thin coat of compound to dry, clean surfaces. Scrub compound into the surface with a stiff-bristle brush. Place concrete while compound is stringy. Do not permit compound to harden prior to concrete placement. Follow manufacturer's instructions regarding safety and health precautions when working with epoxy resins.

3.8.5 Pumping

ACI/MCP-2. Pumping must not result in separation or loss of materials nor cause interruptions sufficient to permit loss of plasticity between successive increments. Loss of slump in pumping equipment must not exceed 50 mm (2 inches). Do not convey concrete through pipe made of aluminum or aluminum alloy. Avoid rapid changes in pipe sizes. Limit maximum size of course aggregate to 33 percent of the diameter of the pipe. Limit maximum size of well rounded aggregate to 40 percent of the pipe diameter. Take samples for testing at both the point of delivery to the pump and at the discharge end.

3.8.5.1 Pumping Lightweight Concrete

ACI/MCP-1. Presoak or presaturate aggregates. Cement content must be minimum of 330 kg per cubic meter (564 pounds per cubic yard) and be sufficient to accommodate a 100 to 150 mm (4 to 6 inch) slump.

3.8.6 Cold Weather

ACI/MCP-2. Do not allow concrete temperature to decrease below 10 degrees C (50 degrees F). Obtain approval prior to placing concrete when the ambient temperature is below 4 degrees C (40 degrees F) or when concrete is likely to be subjected to freezing temperatures within 24 hours. Cover concrete and provide sufficient heat to maintain 10 degrees C (50 degrees F) minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 3 degrees C (37 degrees F) in any 1 hour and 10 degrees C (50 degrees F) per 24 hours after heat application.

3.8.7 Hot Weather

Maintain required concrete temperature using Figure 2.1.5 in ACI/MCP-2 to prevent the evaporation rate from exceeding 1 kg per square meter (0.2 pound of water per square foot) of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. Shade the fresh concrete as soon as possible after placing. Start curing when the surface of the fresh concrete is sufficiently hard to permit curing without damage. Provide water hoses, pipes, spraying equipment, and water hauling equipment, where job site is remote to water source, to maintain a moist concrete surface throughout the curing period. Provide burlap cover or other suitable, permeable material with fog spray or continuous wetting of the concrete when weather conditions prevent the use of either liquid membrane curing compound or impervious sheets. For vertical surfaces, protect forms from direct sunlight and add water to top of structure once concrete is set.

3.8.8 Follow-up

Check concrete within 24 hours of placement for flatness, levelness, and other specified tolerances. Adjust formwork and placement techniques on subsequent pours to achieve specified tolerances.

3.8.9 Placing Concrete in Forms

Deposit concrete placed in forms in horizontal layers not exceeding 600 mm (24 inches).

Remove temporary spreaders in forms when concrete placing has reached elevation of spreaders.

Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Provide vibrating equipment adequate in number of units and power of each unit to properly consolidate concrete. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced points not farther apart than visible effectiveness of machine. Do not insert vibrator into lower courses of concrete that have begun to set. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of concrete mix.

Do not start placing of concrete in supporting elements until concrete previously placed in columns and walls is no longer plastic and has been in place a minimum of 2 hours.

3.8.10 Placing Concrete Slabs

Place and consolidate concrete for slabs in a continuous operation, within the limits of approved construction joints until placing of panel or section is completed.

During concrete placing operations, consolidate concrete by mechanical vibrating equipment so that concrete is worked around reinforcement and other embedded items and into corners. Consolidate concrete placed in beams and girders of supported slabs and against bulkheads of slabs on ground by mechanical vibrators as specified. Consolidate concrete in remainder of slabs by vibrating bridge screeds, roller pipe screeds, or other approved method. Limit consolidation operations to time necessary to obtain consolidation of concrete without bringing an excess of fine aggregate to the surface. Concrete to be consolidated must be as dry as practical and surfaces thereof must not be manipulated prior to finishing operations. Bring concrete correct level with a straightedge and struck-off. Use bull floats or darbies to smooth surface, leaving it free of humps or hollows. Sprinkling of water on plastic surface is not permitted.

Provide finish of slabs as specified.

3.8.11 Bonding

Surfaces of set concrete at joints, except where bonding is obtained by use of concrete bonding agent, must be roughened and cleaned of laitance, coatings, loose particles, and foreign matter. Roughen surfaces in a manner that exposes the aggregate uniformly and does not leave laitance, loosened particles of aggregate, nor damaged concrete at the surface.

Obtain bonding of fresh concrete that has set as follows:

At joints between footings and walls or columns, between walls or columns and the beams or slabs they support, and elsewhere unless otherwise specified; roughened and cleaned surface of set concrete must be dampened, but not saturated, immediately prior to placing of fresh concrete.

At joints in exposed-to-view work; at vertical joints in walls; at joints near midpoint of span in girders, beams, supported slabs, other structural members; in work designed to contain liquids; the roughened and cleaned surface of set concrete must be dampened but not saturated and covered with a cement grout coating.

Provide cement grout that consists of equal parts of portland cement and fine aggregate by weight with not more than 22.5 liters (6 gallons) of water per sack of cement. Apply cement grout with a stiff broom or brush to a minimum thickness of 1.6 mm (1/16 inch). Deposit fresh concrete before cement grout has attained its initial set.

Bonding of fresh concrete to concrete that has set may be obtained by use of a concrete bonding agent. Apply such bonding material to cleaned concrete surface in accordance with approved printed instructions of bonding material manufacturer.

3.9 SURFACE FINISHES EXCEPT FLOOR, SLAB, AND PAVEMENT FINISHES

3.9.1 Defects

Repair formed surfaces by removing minor honeycombs, pits greater than 600 square mm (1 square inch) surface area or 6 mm (0.25 inch) maximum depth, or otherwise defective areas. Provide edges perpendicular to the surface and patch with nonshrink grout. Patch tie holes and defects when the forms are removed. Concrete with extensive honeycomb including exposed steel reinforcement, cold joints, entrapped debris, separated aggregate, or other defects which affect the serviceability or structural strength will be rejected, unless correction of defects is approved. Obtain approval of corrective action prior to repair. The surface of the concrete must not vary more than the allowable tolerances of ACI/MCP-4. Exposed surfaces must be uniform in appearance and finished to a smooth form finish unless otherwise specified.

3.9.2 Not Against Forms (Top of Walls)

Surfaces not otherwise specified must be finished with wood floats to even surfaces. Finish must match adjacent finishes.

3.9.3 Formed Surfaces

3.9.3.1 Tolerances

ACI/MCP-1 and as indicated.

3.9.3.2 As-Cast Rough Form

Provide for surfaces not exposed to public view. Patch these holes and defects and level abrupt irregularities. Remove or rub off fins and other projections exceeding 6 mm (0.25 inch) in height.

3.9.3.3 Standard Smooth Finish

Finish must be as-cast concrete surface as obtained with form facing material for standard smooth finish. Repair and patch defective areas as specified; and all fins and remove other projections on surface.

3.9.4 Grout Finish

Provide finish that is standard, smooth coated with grout as specified.

Give finish to interior and exterior concrete vertical surfaces that are to be exposed to view.

Grout is required consisting of one part portland cement to 1-1/2 parts fine aggregate by volume, mixed with water to produce a consistency of thick paint. Portland cement portion must be a blend of standard portland cement and white portland cement, proportioned as determined by trial mixes so that final color of grout when dry approximates color of surrounding concrete. Fine aggregate must pass 600 micrometer (No. 30) mesh sieve.

Surface of concrete is required to be wetted, and grout must be applied immediately to wetted surfaces. Spread grout over surface with clean burlap pads or sponge-rubber floats to fill pits, air bubbles, and surface holes. Remove excess grout by scraping, then rubbing surface with clean burlap to remove visible grout film. Keep grout damp by means of fog spray during setting period. Complete finish the day it is started, and make limits of a finished area at natural breaks in finished surface.

3.10 FLOOR, SLAB, AND PAVEMENT FINISHES AND MISCELLANEOUS CONSTRUCTION

ACI/MCP-2, unless otherwise specified. Slope floors uniformly to drains where drains are provided. Depress the concrete base slab where quarry tile, ceramic tile are indicated. Steel trowel and fine-broom finish concrete slabs that are to receive quarry tile, ceramic tile, or paver tile. Where straightedge measurements are specified, Contractor must provide straightedge.

3.10.1 Finish

Place, consolidate, and immediately strike off concrete to obtain proper contour, grade, and elevation before bleedwater appears. Permit concrete to attain a set sufficient for floating and supporting the weight of the finisher and equipment. If bleedwater is present prior to floating the surface, drag the excess water off or remove by absorption with porous materials. Do not use dry cement to absorb bleedwater.

3.10.1.1 Scratched

Use for surfaces intended to receive bonded applied cementitious applications. After the concrete has been placed, consolidated, struck off, and leveled to a Class C tolerance as defined below,roughen the surface with stiff brushes of rakes before final set.

3.10.1.2 Floated

Use for surfaces to receive roofing, waterproofing membranes, sand bed terrazzo, and exterior slabs, unless otherwise indicated. After the concrete has been placed, consolidated, struck off, and leveled, do not work the concrete further, until ready for floating. Whether floating with a wood, magnesium, or composite hand float, with a bladed power trowel equipped with float shoes, or with a powered disc, float must begin when the surface has stiffened sufficiently to permit the operation. During or after the first floating, check surface with a 3 meter (10 foot) straightedge applied at no less than two different angles, one of which is perpendicular to the direction of strike off. Cut down high spots and fill low spots during this procedure to produce a surface level within 6 mm in 3 m (1/4 inch) in 10 feet).

3.10.1.3 Steel Troweled

Use for floors intended as walking surfaces and for reception of floor coverings. First, provide a floated finish. Next, the finish must be power troweled two times, and finally hand troweled. The first troweling after floating needs to produce a smooth surface which is relatively free of defects but which may still show some trowel marks. Perform additional trowelings done by hand after the surface has hardened sufficiently. The final troweling is done when a ringing sound is produced as the trowel is moved over the surface. Thoroughly consolidate the surface by the hand troweling operations. The finished surface must be essentially free of trowel marks and uniform in texture and appearance. The finished surface must produce a surface level to within 6 mm in 3 m (1/4 inch in 10 feet). On surfaces intended to support floor coverings, remove any defects of sufficient magnitude to show through the floor covering by grinding.

3.10.1.4 Nonslip Finish

Use on surfaces of exterior platforms, steps, and landings; and on exterior and interior pedestrian ramps. Apply dry shake aggregate of ceramically bonded aluminum oxide to the surface at a minimum rate of 1.2 kg per square m (25 pounds per 100 square feet). Blend approximately two-thirds of the aggregate with portland cement as recommended by the manufacturer and apply to the surface evenly and without segregation. After blended material has been embedded by floating, apply the remainder of the blended material to the surface at right angles to the previous application. Apply blended material heavier in any areas not sufficiently covered by the first application. Perform a second floating immediately following the first. After the selected material has been embedded by the two floatings, complete the operation with a broomed, floated or troweled finish.

3.10.1.5 Broomed

Use on surfaces of exterior walks, platforms, patios, and ramps, unless otherwise indicated. Perform a floated finish, then draw a broom or burlap belt across the surface to produce a coarse scored texture. Permit surface to harden sufficiently to retain the scoring or ridges. Broom transverse to traffic or at right angles to the slope of the slab.

3.10.1.6 Pavement

Screed the concrete with a template advanced with a combined longitudinal and crosswise motion. Maintain a slight surplus of concrete ahead of the template. After screeding, float the concrete longitudinally. Use a straightedge to check slope and flatness; correct and refloat as necessary. Obtain final finish by belting. Lay belt flat on the concrete surface and advance with a sawing motion; continue until a uniform but gritty nonslip surface is obtained. Round edges and joints with an edger having a radius of 3 mm (1/8 inch).

3.10.1.7 Concrete Toppings Placement

The following requirements apply to the placement of toppings of concrete on base slabs that are either freshly placed and still plastic, or on hardened base slabs.

a. Placing on a Fresh Base: Screed and bull float the base slab. As soon as the water sheen has disappeared, lightly rake the surface of the base slab with a stiff bristle broom to produce a bonding surface for the topping. Immediately spread the topping mixture evenly over the roughened base before final set takes place. Give the topping the finish indicated on the drawings.

b. Bonding to a Hardened Base: When the topping is to be bonded to a floated or troweled hardened base, roughen the base by scarifying, grit-blasting, scabbling, planing, flame cleaning, or acid-etching to lightly expose aggregate and provide a bonding surface. Remove dirt, laitance, and loose aggregate by means of a stiff wire broom. Keep the clean base wet for a period of 12 hours preceding the application of the topping. Remove excess water and apply a 1:1:1/2 cement-sand-water grout, and brush into the surface of the base slab. Do not allow the cement grout to dry, and spread it only short distances ahead of the topping placement. Do not allow the temperature differential between the completed base and the topping mixture to exceed 5 degrees C (41 degrees F) at the time of placing. Place the topping and finish as indicated.

3.10.1.8 Chemical-Hardener Treatment

Apply liquid-chemical floor hardener where indicated after curing and drying concrete surface. Dilute liquid hardener with water and apply in three coats. First coat must be one-third strength, second coat one-half strength, and third coat two-thirds strength. Apply each coat evenly and allow to dry 24 hours between coats.

Approved proprietary chemical hardeners must be applied in accordance with manufacturer's printed directions.

3.10.1.9 Colored Wear-Resistant Finish

Give finish to monolithic slab surfaces where indicated.

Apply dry shake materials for colored wear-resistant finish at the rate of 29 kilogram per 10 square meter (60 pounds per 100 square feet) of surface.

Immediately following first floating operation, approximately two-thirds of specified weight of dry shake material must be uniformly distributed over surface and embedded by means of power floating. After first dry-shake application has been embedded, uniformly distribute remainder of dry-shake material over surface at right angles to first dry-shake application and embed by means of power floating. Trueness of surface and other requirements for floating operations not specified in this paragraph must be as specified for float finish.

After completion of float finish, apply a trowel finish as specified.

3.10.1.10 Heavy-Duty Wear-Resistant Finish

Give finish to slab surfaces where indicated.

Dry-shake material for heavy-duty, wear-resistant finish must consist of a mixture of standard portland cement and aggregate for heavy-duty, wear-resistant finish proportioned by weight as follows:

One part standard portland cement and two parts traprock aggregate for heavy-duty wear-resistant finish, four parts emery aggregate for heavy-duty wear-resistant finish, or two parts by weight iron aggregate for heavy-duty, wear-resistant finish.

Apply blended dry-shake material as follows:

MAXIMUM TYPE OF AGGREGATE IN DRY SHAKE	AMOUNT PER 100 SQUARE METER (feet) OF SURFACE
Traprock	73 kilogram (160 pounds)
Emery	59 kilogram (130 pounds)
Iron	59 kilogram (130 pounds)

Immediately following the first floating operation, approximately one-half the specified weight of blended, uniformly distribute dry-shake materials over the surface and embedded by means of power floating. After the first dry-shake application has been embedded, uniformly distribute the remaining one-half of the blended dry-shake material over the surface at right angles to the first dry-shake application and embedded by means of power floating. Trueness of surface and other requirements for floating operations not specified in this paragraph must be as specified for float finish.

After completion of the float finish, trowel finish the surface as specified.

3.10.2 Flat Floor Finishes

ACI/MCP-2. Construct in accordance with one of the methods recommended in Table 7.15.3, "Typical Composite Ff/FL Values for Various Construction Methods." ACI/MCP-1 for tolerance tested by ASTM E1155.

a. Specified Conventional Value:

Floor Flatness (Ff) 20 13 minimum
Floor Levelness (FL) 15 10 minimum

b. Specified Industrial:

Floor Flatness (Ff) 30 15 minimum
Floor Levelness (FL) 20 10 minimum

3.10.2.1 Measurement of Floor Tolerances

Test slab within 24 hours of the final troweling. Provide tests to Contracting Officer within 12 hours after collecting the data. Floor flatness inspector is required to provide a tolerance report which must include:

a. Key plan showing location of data collected.

b. Results required by ASTM E1155.

3.10.2.2 Remedies for Out of Tolerance Work

Contractor is required to repair and retest any floors not meeting specified tolerances. Prior to repair, Contractor must submit and receive approval for the proposed repair, including product data from any materials proposed. Repairs must not result in damage to structural integrity of the floor. For floors exposed to public view, repairs must prevent any uneven or unusual coloring of the surface.

3.10.3 Concrete Walks

Provide 100 mm (4 inches) thick minimum. Provide contraction joints spaced every 1500 lineal mm (5 linear feet) unless otherwise indicated. Cut contraction joints 25 mm (one inch) deep with a jointing tool after the surface has been finished. Provide 13 mm (0.5 inch) thick transverse expansion joints at changes in direction where sidewalk abuts curb, steps, rigid pavement, or other similar structures; space expansion joints every 15 m (50 feet) maximum. Give walks a broomed finish. Unless indicated otherwise, provide a transverse slope of 1/48. Limit variation in cross section to 6 mm in 1500 mm (1/4 inch in 5 feet).

3.10.4 Pits and Trenches

Place bottoms and walls monolithically or provide waterstops and keys.

3.10.5 Curbs and Gutters

Provide contraction joints spaced every 3 m (10 feet) maximum unless otherwise indicated. Cut contraction joints 20 mm (3/4 inch) deep with a jointing tool after the surface has been finished. Provide expansion joints 13 mm (1/2 inch) thick and spaced every 30 m (100 feet) maximum unless otherwise indicated. Perform pavement finish.

3.10.6 Splash Blocks

Provide at outlets of downspouts emptying at grade. Splash blocks may be precast concrete, and must be 600 mm (24 inches) long, 300 mm (12 inches) wide and 100 mm (4 inches) thick, unless otherwise indicated, with smooth-finished countersunk dishes sloped to drain away from the building.

3.11 CURING AND PROTECTION

ACI/MCP-2 unless otherwise specified. Begin curing immediately following form removal. Avoid damage to concrete from vibration created by blasting, pile driving, movement of equipment in the vicinity, disturbance of formwork or protruding reinforcement, and any other activity resulting in ground vibrations. Protect concrete from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks, and oil stains. Do not allow concrete to dry out from time of placement until the expiration of the specified curing period. Do not use membrane-forming compound on surfaces where appearance would be objectionable, on any surface to be painted, where coverings are to be bonded to the concrete, or on concrete to which other concrete is to be bonded. If forms are removed prior to the expiration of the curing period, provide another curing procedure specified herein for the remaining portion of the curing period. Provide moist curing for those areas receiving liquid chemical sealer-hardener or epoxy coating. Allow curing compound/sealer installations to cure prior to the installation of materials that adsorb VOCs.

3.11.1 General

Protect freshly placed concrete from premature drying and cold or hot temperature and maintain without drying at a relatively constant temperature for the period of time necessary for hydration of cement and proper hardening of concrete.

Start initial curing as soon as free water has disappeared from surface of concrete after placing and finishing. Keep concrete moist for minimum 72 hours.

Final curing must immediately follow initial curing and before concrete has dried. Continue final curing until cumulative number of hours or fraction thereof (not necessarily consecutive) during which temperature of air in contact with the concrete is above 10 degrees C (50 degrees F) has totaled 168 hours. Alternatively, if tests are made of cylinders kept adjacent to the structure and cured by the same methods, final curing may be terminated when the average compressive strength has reached 70 percent of the 28-day design compressive strength. Prevent rapid drying at end of final curing period.

3.11.2 Moist Curing

Remove water without erosion or damage to the structure. Prevent water run-off.

3.11.2.1 Ponding or Immersion

Continually immerse the concrete throughout the curing period. Water must not be more than 10 degrees C (50 degrees F) less than the temperature of the concrete. For temperatures between 4 and 10 degrees C (40 and 50 degrees F), increase the curing period by 50 percent.

3.11.2.2 Fog Spraying or Sprinkling

Apply water uniformly and continuously throughout the curing period. For temperatures between 4 and 10 degrees C (40 and 50 degrees F), increase the curing period by 50 percent.

3.11.2.3 Pervious Sheeting

Completely cover surface and edges of the concrete with two thicknesses of wet sheeting. Overlap sheeting 150 mm (6 inches) over adjacent sheeting. Provide sheeting that is at least as long as the width of the surface to be cured. During application, do not drag the sheeting over the finished concrete nor over sheeting already placed. Wet sheeting thoroughly and keep continuously wet throughout the curing period.

3.11.2.4 Impervious Sheeting

Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 300 mm (12 inches) minimum. Provide sheeting not less than 450 mm (18 inches) wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Cover or wrap columns, walls, and other vertical structural elements from the top down with impervious sheeting; overlap and continuously tape sheeting joints; and introduce sufficient water to soak the entire surface prior to completely enclosing.

3.11.3 Liquid Membrane-Forming Curing Compound

Seal or cover joint openings prior to application of curing compound. Prevent curing compound from entering the joint. Apply in accordance with the recommendations of the manufacturer immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. Provide and maintain compound on the concrete surface throughout the curing period. Do not use this method of curing where the use of Figure 2.1.5 in ACI/MCP-2 indicates that hot weather conditions cause an evaporation rate exceeding one kg pf water per square meter per hour (0.2 pound of water per square foot per hour).

3.11.3.1 Application

Unless the manufacturer recommends otherwise, apply compound immediately after the surface loses its water sheen and has a dull appearance, and before joints are sawed. Mechanically agitate curing compound thoroughly during use. Use approved power-spraying equipment to uniformly apply two coats of compound in a continuous operation. The total coverage for the two coats must be 5 square meters maximum per L (200 square feet maximum per gallon) of undiluted compound unless otherwise recommended by the manufacturer's written instructions. The compound must form a uniform, continuous, coherent film that does not check, crack, or peel. Immediately apply an additional coat of compound to areas where the film is defective. Re-spray concrete surfaces subjected to rainfall within 3 hours after the curing compound application.

3.11.3.2 Protection of Treated Surfaces

Prohibit pedestrian and vehicular traffic and other sources of abrasion at least 72 hours after compound application. Maintain continuity of the coating for the entire curing period and immediately repair any damage.

3.11.4 Liquid Chemical Sealer-Hardener

Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's recommendations. Seal or cover joints and openings in which joint sealant is to be applied as required by the joint sealant manufacturer. Do not apply the sealer hardener until the concrete has been moist cured and has aged for a minimum of 30 days. Apply a minimum of two coats of sealer-hardener.

3.11.5 Requirements for Type III, High-Early-Strength Portland Cement

The curing periods are required to be not less than one-fourth of those specified for portland cement, but in no case less than 72 hours.

3.11.6 Curing Periods

ACI/MCP-2 except 10 days for retaining walls, pavement or chimneys, 21 days for concrete that is in full-time or intermittent contact with seawater, salt spray, alkali soil or waters. Begin curing immediately after placement. Protect concrete from premature drying, excessively hot temperatures, and mechanical injury; and maintain minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing are subject to approval by the Contracting Officer.

3.11.7 Curing Methods

Accomplish curing by moist curing, by moisture-retaining cover curing, by membrane curing, and by combinations thereof, as specified.

Moist curing:

Accomplish moisture curing by any of the following methods:

Keeping surface of concrete wet by covering with water

Continuous water spraying

Covering concrete surface with specified absorptive cover for curing concrete saturated with water and keeping absorptive cover wet by water spraying or intermittent hosing. Place absorptive cover to provide coverage of concrete surfaces and edges with a slight overlap over adjacent absorptive covers.

Moisture-cover curing:

Accomplish moisture-retaining cover curing by covering concrete surfaces with specified moisture-retaining cover for curing concrete. Place cover directly on concrete in widest practical width, with sides and ends lapped at least 75 mm (3 inches). Weight cover to prevent displacement; immediately repair tears or holes appearing during curing period by patching with pressure-sensitive, waterproof tape or other approved method.

Membrane curing:

Accomplish membrane curing by applying specified membrane-forming curing compound to damp concrete surfaces as soon as moisture film has disappeared. Apply curing compound uniformly in a two-coat operation by power-spraying equipment using a spray nozzle equipped with a wind guard. Apply second coat in a direction at right angles to direction of first coat. Total coverage for two coats must be not more than 5 square meter per liter (200 square feet per gallon) of curing compound. Respray concrete surfaces which are subjected to heavy rainfall within 3 hours after curing compound has been applied by method and at rate specified. Maintain continuity of coating for entire curing period and immediately repair damage to coating during this period.

Membrane-curing compounds must not be used on surfaces that are to be covered with coating material applied directly to concrete or with a covering material bonded to concrete, such as other concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, painting, and other coatings and finish materials.

3.11.8 Curing Formed Surfaces

Accomplish curing of formed surfaces, including undersurfaces of girders, beams, supported slabs, and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed before end of curing period, accomplish final curing of formed surfaces by any of the curing methods specified above, as applicable.

3.11.9 Curing Unformed Surfaces

Accomplish initial curing of unformed surfaces, such as monolithic slabs, floor topping, and other flat surfaces, by membrane curing.

Unless otherwise specified, accomplish final curing of unformed surfaces by any of curing methods specified above, as applicable.

Accomplish final curing of concrete surfaces to receive liquid floor hardener of finish flooring by moisture-retaining cover curing.

3.11.10 Temperature of Concrete During Curing

When temperature of atmosphere is 5 degrees C (41 degrees F) and below, maintain temperature of concrete at not less than 13 degrees C (55 degrees F) throughout concrete curing period or 7 degrees C (45 degrees F) when the curing period is measured by maturity. When necessary, make arrangements before start of concrete placing for heating, covering, insulation, or housing as required to maintain specified temperature and moisture conditions for concrete during curing period.

When the temperature of atmosphere is 27 degrees C (80 degrees F) and above or during other climatic conditions which cause too rapid drying of concrete, make arrangements before start of concrete placing for installation of wind breaks, of shading, and for fog spraying, wet sprinkling, or moisture-retaining covering of light color as required to protect concrete during curing period.

Changes in temperature of concrete must be uniform and not exceed 3 degrees C (37 degrees F) in any 1 hour nor 27 degrees C (80 degrees F) in any 24-hour period.

3.11.11 Protection from Mechanical Injury

During curing period, protect concrete from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration and from damage caused by rain or running water.

3.11.12 Protection After Curing

Protect finished concrete surfaces from damage by construction operations.

3.12 FIELD QUALITY CONTROL

3.12.1 Sampling

ASTM C172/C172M or KS F 2401. Collect samples of fresh concrete to perform tests specified. ASTM C31/C31M or KS F 2403 for making test specimens.

3.12.2 Testing

3.12.2.1 Slump Tests

ASTM C143/C143M or KS F 2402. Take concrete samples during concrete placement. The maximum slump may be increased as specified with the addition of an approved admixture provided that the water-cement ratio is not exceeded. Perform tests at commencement of concrete placement, when test cylinders are made, and for each batch (minimum) or every 16 cubic meters (20 cubic yards) (maximum) of concrete.

3.12.2.2 Temperature Tests

Test the concrete delivered and the concrete in the forms. Perform tests in hot or cold weather conditions (below 10 degrees C and above 27 degrees C (below 50 degrees F and above 80 degrees F)) for each batch (minimum) or every 16 cubic meters (20 cubic yards) (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

3.12.2.3 Compressive Strength Tests

ASTM C39/C39M or KS F 2405. Make five test cylinders for each set of tests in accordance with ASTM C31/C31M or KS F 2403. Take precautions to prevent evaporation and loss of water from the specimen. Test two cylinders at 7 days, two cylinders at 28 days, and hold one cylinder in reserve. Take samples for strength tests of each mix design of concrete placed each day not less than once a day, nor less than once for each 120 cubic meters (160 cubic yards) of concrete, nor less than once for each 500 square meters (5400 square feet) of surface area for slabs or walls. For the entire project, take no less than five sets of samples and perform strength tests for each mix design of concrete placed. Each strength test result must be the average of two cylinders from the same concrete sample tested at 28 days. If the average of any three consecutive strength test results is less than f'c or if any strength test result falls below f'c by more than 3 MPa (450 psi), take a minimum of three ASTM C42/C42M or KS F 2422 core samples from the in-place work represented by the low test cylinder results and test. Concrete represented by core test is considered structurally adequate if the average of three cores is equal to at least 85 percent of f'c and if no single core is less than 75 percent of f'c. Retest locations represented by erratic core strengths. Remove concrete not meeting strength criteria and provide new acceptable concrete. Repair core holes with nonshrink grout. Match color and finish of adjacent concrete.

3.12.2.4 Air Content

ASTM C173/C173M or ASTM C231/C231M for normal weight concrete and ASTM C173/C173M for lightweight concrete. Test air-entrained concrete for air content at the same frequency as specified for slump tests.

3.12.2.5 Unit Weight of Structural Lightweight Concrete

ASTM C567/C567M. Determine unit weight of lightweight concrete. Perform test for every 15 cubic meters (20 cubic yards) maximum.

3.12.2.6 Ion Concentration

ACI/MCP-3. Determine water soluble ion concentration. Perform test once for each mix design.

3.12.2.7 Strength of Concrete Structure

Compliance with the following is considered deficient if it fails to meet the requirements which control strength of structure in place, including following conditions:

Failure to meet compressive strength tests as evaluated

Reinforcement not conforming to requirements specified

Concrete which differs from required dimensions or location in such a manner as to reduce strength

Concrete curing and protection of concrete against extremes of temperature during curing, not conforming to requirements specified

Concrete subjected to damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration

Poor workmanship likely to result in deficient strength

3.12.2.8 Testing Concrete Structure for Strength

When there is evidence that strength of concrete structure in place does not meet specification requirements, make cores drilled from hardened concrete for compressive strength determination in accordance with ASTM C42/C42M or KS F 2422, and as follows:

Take at least three representative cores from each member or area of concrete-in-place that is considered potentially deficient. Location of cores will be determined by the Contracting Officer.

Test cores after moisture conditioning in accordance with ASTM C42/C42M or KS F 2422 if concrete they represent is more than superficially wet under service.

Air dry cores, (16 to 27 degrees C 60 (to 80 degrees F)with relative humidity less than 60 percent) for 7 days before test and test dry if concrete they represent is dry under service conditions.

Strength of cores from each member or area are considered satisfactory if their average is equal to or greater than 85 percent of the 28-day design compressive strength of the class of concrete.

Core specimens will be taken and tested by the Government. If the results of core-boring tests indicate that the concrete as placed does not conform to the drawings and specification, the cost of such tests and restoration required must be borne by the Contractor.

Fill core holes solid with patching mortar and finished to match adjacent concrete surfaces.

Correct concrete work that is found inadequate by core tests in a manner approved by the Contracting Officer.

3.13 WASTE MANAGEMENT

As specified in the Waste Management Plan and as follows.

3.13.1 Reinforcing Steel

Collect reinforcing steel and place in designated area for recycling.

3.13.2 Other Waste

Identify concrete manufacturer's or supplier's policy for collection or return of construction waste, unused material, deconstruction waste, and/or packaging material.

3.14 JOINTS

3.14.1 Construction Joints

Make and locate joints not indicated so as not to impair strength and appearance of the structure, as approved. Locate construction joints as follows:

a. In walls at not more than 18.3 meter (60 feet) in any horizontal direction; at top of footing; at top of slabs on ground; at top and bottom of door and window openings or where required to conform to architectural details; and at underside of deepest beam or girder framing into wall

b. In columns or piers, at top of footing; at top of slabs on ground; and at underside of deepest beam or girder framing into column or pier

c. Near midpoint of spans for supported slabs, beams, and girders unless a beam intersects a girder at the center, in which case construction joints in girder must offset a distance equal to twice the width of the beam. Make transfer of shear through construction joint by use of inclined reinforcement.

d. In slabs on ground, so as to divide slab into areas not in excess of 111.5 square meter (1,200 square feet)

Provide keyways at least 40 mm (1-1/2-inches) deep in construction joints in walls and slabs and between walls and footings; approved bulkheads may be used for slabs.

Joints must be perpendicular to main reinforcement. Reinforcement must be continued across construction joints.

3.14.2 Waterstops

Provide waterstops in construction joints as indicated.

Install waterstops to form a continuous diaphragm in each joint. Make adequate provisions to support and protect waterstops during progress of work. Make field joints in waterstops in accordance with waterstop manufacturer's printed instructions, as approved. Protect waterstops protruding from joints from damage.

3.14.3 Isolation Joints in Slabs on Ground

Provide joints at points of contact between slabs on ground and vertical surfaces, such as column pedestals, foundation walls, grade beams, and elsewhere as indicated.

Fill joints with premolded joint filler strips 13 mm (1/2 inch) thick, extending full slab depth. Install filler strips at proper level below finish floor elevation with a slightly tapered, dress-and-oiled wood strip temporarily secured to top of filler strip to form a groove not less than 19 mm (3/4 inch) in depth where joint is sealed with sealing compound and not less than 6 mm (1/4 inch)in depth where joint sealing is not required. Remove wood strip after concrete has set. Contractor must clean groove of foreign matter and loose particles after surface has dried.

3.14.4 Control Joints in Slabs on Ground

Provide joints to form panels as indicated.

Under and on exact line of each control joint, cut 50 percent of welded wire fabric reinforcement before placing concrete.

Joints must be 4 mm (1/8-inch) wide by 1/5 to 1/4 of slab depth and formed by inserting hand-pressed fiberboard strip into fresh concrete until top surface of strip is flush with slab surface or by cutting the concrete with a saw after the concrete has set. After concrete has cured for at least 7 days, the Contractor must remove inserts and clean groove of foreign matter and loose particles.

3.14.5 Sealing Joints in Slabs on Ground

Isolation and control joints which are to receive finish flooring material must be sealed with joint sealing compound after concrete curing period. Slightly under fill groove with joint sealing compound to prevent extrusion of compound. Remove excess material as soon after sealing as possible.

Sealing is not required for isolation and control joints to be covered with finish flooring material. Groove must be left ready to receive filling material that is provided as part of finish floor covering work.

3.15 INSTALLATION OF ANCHORAGE DEVICES

3.15.1 General

Anchorage devices and embedded items required for other work that is attached to, or supported by, set and build in cast-in-place concrete as part of the work of this section, using setting drawings, instructions, and directions for work to be attached thereto.

3.15.2 Placing Anchorage Devices

Anchorage devices and embedded items must be positioned accurately and supported against displacement. Fill openings in anchorage devices such as slots and threaded holes with an approved, removable material to prevent entry of concrete into openings.

3.16 CONCRETE CONVEYING

3.16.1 Transfer of Concrete At Project Site

Handle concrete from point of delivery and transfer to concrete conveying equipment and to locations of final deposit as rapidly as practical by methods which prevent segregation and loss of concrete mix materials.

3.16.2 Mechanical Equipment for Conveying Concrete

Equipment must ensure a continuous flow of concrete at delivery end, as approved. Provide runways for wheeled concrete-conveying equipment from concrete delivery point to locations of final deposit. Interior surfaces of concrete conveying equipment must be free of hardened concrete, debris, water, snow, ice, and other deleterious substances.

3.17 CONCRETE FLOOR TOPPING

3.17.1 Standard Floor Topping

Provide topping for treads and platforms of metal steel stairs and elsewhere as indicated.

Materials

Provide materials that conform to requirements specified, except aggregate must be as follows:

TYPE OF AGGREGATE	SIEVE	PERCENT PASSING
Fine aggregate	9.5 mm (3/8 in.)	100
	4.75 mm (No. 4)	95 to 100
	2.36 mm (No. 8)	80 to 90
	1.18 mm (No. 16)	50 to 75
	600 micrometer (No. 30)	30 to 50
	300 micrometer (No. 50)	10 to 20
	150 micrometer (No. 100)	2 to 5
Coarse aggregate	12.5 mm (1/2 in.)	100
	9.5 mm (3/8 in.)	95 to 100
	4.75 mm (No. 4)	40 to 60
	2.36 mm (No. 8)	0 to 5

Standard Topping Mixture

Provide mixture that consists of one part portland cement, one part fine aggregate, and two parts coarse aggregate, by volume. Adjust exact proportions of fine and coarse aggregates to produce a well-graded total aggregate. Mixing water must not exceed 5 gallons) per 94-pound sack of cement including unabsorbed moisture in aggregate. Maximum slump must be 50 mm (2 inches).

Preparations Prior to Placing

When mixture is placed on a green concrete base slab, screed surface of base slab to a level not more than 38 mm (1-1/2 inches) nor less than 25 mm (1 inch) below required finish surface. Remove water and laitance from surface of base slab before placing topping mixture. As soon as water ceases to rise to surface of base slab, place topping mixture as specified.

When mixture is placed on a hardened concrete base slab, remove dirt, loose material, oil, grease, asphalt, paint, and other contaminants from base slab surface, leaving a clean surface. Prior to placing topping mixture, (64 mm (2-1/2-inches) minimum) slab surface must be dampened and left free of standing water. Immediately before topping mixture is placed, broom a coat of neat cement grout onto surface of slab. Do not allow cement grout to set or dry before topping mixture is placed.

When mixture is placed on a metal surface, such as metal pans for steel stairs, remove dirt, loose material, oil, grease, asphalt, paint, and other contaminants from metal surface. Immediately before topping mixture is placed, spray or brush a coating of concrete bonding agent onto metal surfaces and do not be allow to set or dry before topping mixture is applied.

Mixing

Do the mixing of topping material at the site in a mechanical mixer of the batch type. Equip batch mixer with a suitable charging hopper, water storage tank, and water-measuring device and must be capable of mixing aggregates, cement, and water into a uniform mix within specified mixing time and of discharging mix without segregation. Provide mixer that bear a rating plate indicating rated capacity and recommended revolutions per minute.

Mix each batch of 1.5 cubic meter (2 cubic yards) or less for not less than 1-1/2 minutes. Increase mixing time 15 seconds for each additional cubic yard or fraction thereof.

Clean mixer, and replace blades in drum when they have lost 10 percent of their original depth.

Truck-mixed topping may be used when approved. Specify truck-mixed topping for ready-mix concrete.

Placing

Spread standard topping mixture evenly on previously prepared base slab or metal surface, brought to correct level with a straightedge, and struck off. Topping must be consolidated, floated, checked for trueness of surface, and refloated as specified for float finish.

Finishing

Give trowel finish standard floor topping surfaces.

Give other finishes standard floor topping surfaces as indicated. Specify such finishes for required finish.

3.17.2 Heavy-Duty Floor Topping

Provide topping where indicated.

Heavy-duty Topping Mixture

Provide mixture that consists of 1 part portland cement and 2-1/2 parts emery aggregate or 1 part fine aggregate and 1-1/2 parts traprock coarse aggregate, by volume. Exact proportions of mixture must conform to recommendations of aggregate manufacturer. Mixing water must not exceed 14.2 liter per 43 kilogram (3-1/4 gallons per 94-pound) sack of cement including unabsorbed moisture in aggregate. Maximum slump must be 25 mm (1 inch).

Base Slab

Screed surface of slab to a level no more than 38 mm (1-1/2 inches) nor less than 25 mm (1 inch) below grade of finished floor.

Give slab a scratch finish as specified.

Preparations prior to placing

Remove dirt, loose material, oil, grease, asphalt, paint and other contaminants from base slab surface. Prior to placing topping mixture, dampen slab surface and leave free of standing water. Immediately before topping mixture is placed, broom a coat of neat cement grout onto surface of slab. Allow cement grout to set or dry before topping mixture is placed.

Mixing

Do mixing of topping material at the site in a mechanical mixer of the batch type. Equip batch mixer with a charging hopper, water storage tank, and a water-measuring device and the batch mixer must be capable of mixing aggregates, cement, and water into a uniform mix within the specified mixing time and of discharging mix without segregation. Provide mixer that bears a rating plate indicating rated capacity and recommended revolutions per minute.

Mix each batch of 1.5 cubic meter (2 cubic yards) or less for not less than 1-1/2 minutes.

Increase mixing time 15 seconds for each additional cubic yard or fraction thereof. Clean mixer, and replace pick-up and throw-over blades in drum when they have lost 10 percent of their original depth.

Placing

Spread heavy-duty topping mixture evenly on previously prepared base slab, and bring to correct level with a straightedge, and strike off. Provide topping that is consolidated, floated, and checked for trueness of surface as specified for float finish, except that power-driven floats is the impact type.

Finishing

Give trowel finish heavy-duty floor topping surfaces. Provide trowel finish as specified, except that additional troweling after first power troweling must be not less than three hand-troweling operations.

-- End of Section --

SECTION 03 30 53

MISCELLANEOUS CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

Perform all work in accordance with ACI MCP SET Parts 2 and 3.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI MCP SET	(2012) Manual of Concrete Practice

ASTM INTERNATIONAL (ASTM)

ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C685/C685M	(2011) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2013) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C990	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2628	(1991; R 2011) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM E1155	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1155M	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)

ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 247	Comprehensive Procurement Guideline for Products Containing Recovered Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2011) Steel Bars for Concrete Reinforcement
KS D 7017	(2007) Welded Steel Wire Fabrics
KS F 2401	(2007) Method of Sampling Fresh Concrete
KS F 2402	(2007) Slump of Concrete
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2526	(2007) Aggregate for Concrete
KS F 2538	(2005) Specification for preformed expansion joint fillers for concrete paving and structural construction
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 3110	(2007) Plywood for Concrete Form
KS F 4007	(2002) Sheet Materials for Curing Concrete
KS F 4009	(2011) Ready-Mixed Concrete
KS F 8006	(2009) Steel Framed Plywood Form
KS L 5201	(2013) Portland Cement
KS L 5508	(2007) Fly Ash and Other Pozzolans for Use with Lime
KS M 3805	(2004) Flexible Polyvinylchloride Water-Stops

1.3 SYSTEM DESCRIPTION

1.3.1 Strength

Acceptance test results are the average strengths of two specimens tested at 28 days (90 days if pozzolan is used). The strength of the concrete is considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength, f'c, and no individual acceptance test result falls below f'c by more than 3.4 MPa (500 psi).

1.3.2 Construction Tolerances

Apply a Class "C" finish to all surfaces except those specified to receive a Class "D" finish. Apply a Class "D" finish to all post-construction surfaces which will be permanently concealed. Surface requirements for the classes of finish required are as specified in Part 4 of ACI MCP SET.

1.3.3 Concrete Mixture Proportions

Concrete mixture proportions are the responsibility of the Contractor. Mixture proportions shall include the dry weights of cementitious material(s); the nominal maximum size of the coarse aggregate; the specific gravities, absorptions, and saturated surface-dry weights of fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per cubic meter (yard) of concrete. Provide materials included in the mixture proportions of the same type and from the same source as will be used on the project. Specified compressive strength f'c shall be 20.7 MPa (3,000 psi) at 28 days (90 days if pozzolan is used). The maximum nominal size coarse aggregate is 25 mm (1 inch), in accordance with ACI MCP SET Part 3, unless otherwise indicated. The air content shall be between 4.5 and 7.5 percent with a slump between 50 and 125 mm (2 and 5 inches). The maximum water cement ratio is 0.50. Submit the applicable test reports and mixture proportions that will produce concrete of the quality required, ten days prior to placement of concrete.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Ready-Mix Concrete

1.5 QUALITY ASSURANCE

Indicate specific locations of Concrete Placement, Forms, Steel Reinforcement, Accessories, Expansion Joints, Construction Joints, Contraction Joints, and Control Joints on installation drawings and include, but not be limited to, square meters (feet) of concrete placements, thicknesses and widths, plan dimensions, and arrangement of cast-in-place concrete section.

1.5.1 Flatness and Levelness of Floor Slabs

Conduct floor flatness and levelness test, (FF and FL respectively), on floor slabs in accordance with the provisions set forth in ASTM E1155M ASTM E1155. Also Zi calculation to be used shall be N min. = A/10. Make floor tolerance measurements by the approved laboratory and inspection service within 24 hours after completion of final troweling operation and before forms and shores have been removed. Take measurements with a Dipstick Auto-Read floor profiler instrument. Provide results of floor tolerance tests, including formal notice of acceptance or rejection of the work, to the Contracting Officer within 24 hours after data collection.

PART 2 PRODUCTS

2.1 MATERIALS

Submit manufacturer's literature from suppliers which demonstrates compliance with applicable specifications for the specified materials.

2.1.1 Cementitious Materials

Submit Manufacturer's certificates of compliance, accompanied by mill test reports, attesting that the concrete materials meet the requirements of the specifications in accordance with the Special Clause "CERTIFICATES OF COMPLIANCE". Also, certificates for all material conforming to EPA's Comprehensive Procurement Guidelines (CPG), in accordance with 40 CFR 247. Provide cementitious materials that conform to the appropriate specifications listed:

2.1.1.1 Portland Cement

ASTM C150/C150M or KS L 5201, Type I, II, or V.

2.1.1.2 Pozzolan

Provide pozzolan that conforms to ASTM C618, Class C or F, including requirements of Tables 1A and 2A, or KS L 5508.

2.1.2 Aggregates

Fine and coarse aggregates shall meet the quality and grading requirements of ASTM C33/C33M Class Designations 4M or better or or KS F 2526. Submit certificates of compliance and test reports for aggregates showing the material(s) meets the quality and grading requirements of the specifications under which it is furnished.

2.1.3 Admixtures

Admixtures to be used, when required or approved, shall comply with the appropriate specification listed. Retest chemical admixtures that have been in storage at the project site, for longer than 6 months or that have been subjected to freezing, at the expense of the Contractor at the request of the Contracting Officer and will be rejected if test results are not satisfactory.

2.1.3.1 Air-Entraining Admixture

Provide air-entraining admixture that meets the requirements of ASTM C260/C260M or KS F 2560.

2.1.3.2 Water-Reducing or Retarding Admixture

Provide water-reducing or retarding admixture meeting the requirements of ASTM C494/C494M, Type A, B, or D.

2.1.4 Water

Minimize the amount of water in the mix. Use fresh, clean, potable water for mixing and curing, free from injurious amounts of oil, acid, salt, or alkali, except that nonpotable water may be used if it meets the requirements of COE CRD-C 400.

2.1.5 Reinforcing Steel

Provide reinforcing bars conforming to the requirements of ASTM A615/A615M, Grade 60 or KS D 3504. Welded steel wire fabric shall conform to the requirements of ASTM A185/A185M or KS D 7017. Details of reinforcement not shown shall be in accordance with ACI MCP SET Part 3, Chapters 7 and 12.

2.1.6 Expansion Joint Filler Strips, Premolded

Expansion joint filler strips, premolded shall be sponge rubber conforming to ASTM D1752, Type I or KS F 2538.

2.1.7 Joint Sealants - Field Molded Sealants

Joint sealants - field molded sealants shall conform to ASTM C920, Type M, Grade NS, Class 25, use NT for vertical joints and Type M, Grade P, Class 25, use T for horizontal joints. Provide polyethylene tape, coated paper, metal foil, or similar type bond breaker materials. The backup material needs to be compressible, nonshrink, nonreactive with the sealant, and a nonabsorptive material such as extruded butyl or polychloroprene foam rubber. Immediately prior to installation of field-molded sealants, clean the joint of all debris and further cleaned using water, chemical solvents, or other means as recommended by the sealant manufacturer or directed.

2.1.8 Waterstops

Waterstops shall conform to COE CRD-C 572 or KS M 3805.

2.1.9 Formwork

The design and engineering of the formwork as well as its construction, will be the responsibility of the Contractor. Submit formwork design prior to the first concrete placement.

2.1.10 Form Coatings

Coat forms, for exposed surfaces, with a nonstaining form oil to be applied shortly before concrete is placed.

2.1.11 Vapor Barrier

Provide polyethylene vapor barrier sheeting with a minimum thickness of 0.15 mm (6 mils) or other equivalent material having a vapor permeance rating not exceeding 30 nanograms per pascal second square meter (0.5 perms) as determined in accordance with ASTM E96/E96M or KS F 4007.

2.1.12 Curing Materials

Provide curing materials conforming to the following requirements.

2.1.12.1 Impervious Sheet Materials

Impervious sheet materials, ASTM C171, type optional, except polyethylene film, if used, shall be white opaque.

2.1.12.2 Membrane-Forming Curing Compound

ASTM C309, Type 1-D or 2, Class A or B.

2.2 READY-MIX CONCRETE

a. Concrete shall be ready-mix concrete with mix design data conforming to ACI MCP SET Part 2 or KS F 4009.

b. Non-exposed concrete elements: 20 megapascal (3000 psi) minimum compressive strength.

c. Direct-exposed concrete elements (including air-conditioned rooms): 34.5 megapascal (5000 psi) minimum compressive strength as determined in 28 calendar days.

d. Slump: 25 to 100 mm (1 to 4 inch) according to ASTM C143/C143M and ACI MCP SET Part 1.

e. Portland Cement conforming to ASTM C150/C150M or KS L 5201 Type I, II, or V.

g. Use one brand and type of cement for formed concrete having exposed-to-view finished surfaces.

h. Air-Entraining Admixtures conforming to ASTM C260/C260M or KS F 2560. Exterior concrete exposed to freezing needs to be air-entrained 5 to 6 percent by volume. Nonair-entrained interior concrete shall have a total air content of 2 to 4 percent by volume.

i. Water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and accelerating admixtures, and water-reducing and retarding admixtures shall conform to ASTM C494/C494M or KS F 2560.

j. Fly Ash used as an supplementary cementitious material shall conform to ASTM C618, Class C or F, or KS L 5508 with 4 percent maximum loss on ignition and 35 percent maximum cement replacement by weight.

k. Ground granulated blast furnace slag used as an supplementary cementitious material shall conform to ASTM C989/C989M, Grade 120 with between 25 to 50 percent maximum cement replacement by weight.

2.3 STEEL REINFORCEMENT

2.3.1 Deformed Steel Bars

Provide steel bars conforming to ASTM A615/A615M, Grade 408 MPa (60 ksi) ACI MCP SET Parts 2 and 3, or KS D 3504.

2.3.2 Welded Wire Fabric

Provide welded wire fabric conforming to ASTM A185/A185M, or KS D 7017.

2.4 FORMS

Forms shall be of wood, steel, or other approved material and conform to ACI MCP SET, Parts 2 and 3, or KS F 3110 or KS F 8006.

Provide form release conforming to ACI MCP SET, Part 4.

2.5 ACCESSORIES

2.5.1 Waterstops

a. Provide waterstops of the flat dumbbell type not less than 5 mm (3/16-inch) thick for widths up to 125 mm (5 inches) and not less than 10 mm (3/8-inch) thick for widths 125 mm (5 inches) and over.

b. Waterstops shall be made of rubber and conform to ASTM D1752 or be made of polyvinylchloride (PVC) and conform ASTM C990M (ASTM C990), ASTM D2628, or KS M 3805.

2.5.2 Chemical Floor Hardener

Provide hardener which is a colorless aqueous solution containing a blend of magnesium fluorosilicate and zinc fluorosilicate combined with a wetting agent. Provide solution that contains not less than 120 gram of fluorosilicates per liter (approximate 0.5 kilogram per 4 liter) (2 pounds of fluorosilicates per gallon). An approved proprietary chemical hardener may be used provided hardener is delivered ready for use in manufacturer's original containers.

2.5.3 Curing Compound

Provide curing compound conforming to ASTM C309.

2.6 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Prepare construction joints to expose coarse aggregate. The surface shall be clean, damp, and free of laitance. Construct ramps and walkways, as necessary, to allow safe and expeditious access for concrete and workmen. Remove snow, ice, standing or flowing water, loose particles, debris, and foreign matter. Earth foundations shall be satisfactorily compacted. Ensure spare vibrators are available. The entire preparation shall be accepted by the Government prior to placing.

3.1.1 Embedded Items

Secure reinforcement in place after joints, anchors, and other embedded items have been positioned. Arrange internal ties so that when the forms are removed the metal part of the tie is not less than 50 mm (2 inches) from concrete surfaces permanently exposed to view or exposed to water on the finished structures. Embedded items shall be free of oil and other foreign matters such as loose coatings or rust, paint, and scale. The embedding of wood in concrete is permitted only when specifically authorized or directed. All equipment needed to place, consolidate, protect, and cure the concrete shall be at the placement site and in good operating condition.

3.1.2 Formwork Installation

Forms shall be properly aligned, adequately supported, and mortar-tight. Provide smooth form surfaces, free from irregularities, dents, sags, or holes when used for permanently exposed faces. Chamfer all exposed joints and edges , unless otherwise indicated.

3.1.3 Vapor Barrier Installation

Apply vapor barriers over gravel fill. Lap edges not less than 150 mm (6 inches). Seal all joints with pressure-sensitive adhesive not less than 50 mm (2 inches) wide. Protect the vapor barrier at all times to prevent injury or displacement prior to and during concrete placement.

3.1.4 Production of Concrete

3.1.4.1 Ready-Mixed Concrete

Provide ready-mixed concrete conforming to ASTM C94/C94M or KS F 4009 except as otherwise specified.

3.1.4.2 Concrete Made by Volumetric Batching and Continuous Mixing

Concrete made by volumetric batching and continuous mixing shall conform to ASTM C685/C685M.

3.1.5 Waterstops

Install and splice waterstops as directed by the manufacturer.

3.2 CONVEYING AND PLACING CONCRETE

Concrete placement is not permitted when weather conditions prevent proper placement and consolidation without approval. When concrete is mixed and/or transported by a truck mixer, deliver the concrete to the site of the work completing the discharge within 1-1/2 hours or 45 minutes when the placing temperature is 30 degrees C (86 degrees F) or greater unless a retarding admixture is used. Convey concrete from the mixer to the forms as rapidly as practicable by methods which prevent segregation or loss of ingredients. Concrete shall be in place and consolidated within 15 minutes after discharge from the mixer. Deposit concrete as close as possible to its final position in the forms and regulate it so that it may be effectively consolidated in horizontal layers 450 mm (18 inches) or less in thickness with a minimum of lateral movement. Carry on the placement at such a rate that the formation of cold joints will be prevented. Submit Methods and equipment for transporting, handling, depositing, and consolidating the concrete prior to the first concrete placement. Perform conveying and placing concrete in conformance with the following:

3.2.1 Consolidation

Consolidate each layer of concrete by rodding, spading, or internal vibrating equipment. Systematically accomplish internal vibration by inserting the vibrator through the fresh concrete in the layer below at a uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator and overlay the adjacent, just-vibrated area by approximately 100 mm (4 inches). Ensure that the vibrator penetrates rapidly to the bottom of the layer and at least 150 mm (6 inches) into the layer below, if such a layer exists. Hold vibrator stationary until the concrete is consolidated and then withdraw it slowly at the rate of about 75 mm (3 inches) per second.

3.2.2 Cold-Weather Requirements

No concrete is to be mixed or placed when the ambient temperature is below 2 degrees C (36 degrees F) or if the ambient temperature is below 5 degrees C (41 degrees F) and falling. Provide suitable covering and other means as approved for maintaining the concrete at a temperature of at least 10 degrees C (50 degrees F) for not less than 72 hours after placing and at a temperature above freezing for the remainder of the curing period. Do not mix salt, chemicals, or other foreign materials with the concrete to prevent freezing. Remove and replace concrete damaged by freezing at the expense of the Contractor.

3.2.3 Hot-Weather Requirements

When the rate of evaporation of surface moisture, as determined by use of Figure 1 of ACI MCP SET Part 2, is expected to exceed 1 kg/square meter (0.2 psf) per hour, provisions for windbreaks, shading, fog spraying, or covering with a light-colored material shall be made in advance of placement, and such protective measures taken as quickly as finishing operations will allow.

3.2.4 Lifts in Concrete

Deposit concrete in horizontal layers not to exceed 600 mm (24 inches) in thickness. Carry on placement at a rate that prevents the formation of cold joints. Place slabs in one lift.

3.3 FORM REMOVAL

Do not remove forms before 24 hours after concrete placement, except as otherwise specifically authorized. Do not remove supporting forms and shoring until the concrete has cured for at least 5 days. When conditions require longer curing periods, forms shall remain in place.

3.4 FINISHING

3.4.1 Temperature Requirement

Do not finish or repair concrete when either the concrete or the ambient temperature is below 10 degrees C (50 degrees F).

3.4.2 Finishing Formed Surfaces

Remove all fins and loose materials , and surface defects including filling of tie holes. Repair all honeycomb areas and other defects. Remove all unsound concrete from areas to be repaired. Surface defects greater than 13 mm (1/2 inch) in diameter and holes left by removal of tie rods in all surfaces not to receive additional concrete shall be reamed or chipped and filled with dry-pack mortar. Brush-coat the prepared area with an approved epoxy resin or latex bonding compound or with a neat cement grout after dampening and filling with mortar or concrete. The cement used in mortar or concrete for repairs to all surfaces permanently exposed to view shall be a blend of portland cement and white cement so that the final color when cured is the same as adjacent concrete.

3.4.3 Finishing Unformed Surfaces

Float finish all unformed surfaces, that are not to be covered by additional concrete or backfill, to elevations shown, unless otherwise specified. Surfaces to receive additional concrete or backfill shall be brought to the elevations shown and left as a true and regular surface. Slope exterior surfaces for drainage unless otherwise shown. Carefully make joints with a jointing tool. Finish unformed surfaces to a tolerance of 10 mm (3/8 inch) for a float finish and 8 mm (5/16 inch) for a trowel finish as determined by a 3 m (10 foot) straightedge placed on surfaces shown on the drawings to be level or having a constant slope. Do not perform finishing while there is excess moisture or bleeding water on the surface. No water or cement is to be added to the surface during finishing.

3.4.3.1 Float Finish

Provide float finished surfaces, screeded and darbied or bull-floated to eliminate the ridges and to fill in the voids left by the screed. In addition, the darby or bull-float shall fill all surface voids and only slightly embed the coarse aggregate below the surface of the fresh concrete. When the water sheen disappears and the concrete supports a person's weight without deep imprint, complete floating. Floating shall embed large aggregates just beneath the surface, remove slight imperfections, humps, and voids to produce a plane surface, compact the concrete, and consolidate mortar at the surface.

3.4.3.2 Trowel Finish

Trowelling shall be done immediately following floating to provide a smooth, even, dense finish free from blemishes including trowel marks. Protect finished surfaces from damage during the construction period.

3.4.3.3 Flat Floor Finishes

In accordance with ACI MCP SET Part 2, construct in accordance with one of the methods recommended in Table 7.15.3, "Typical Composite FF/FL Values for Various Construction Methods." ACI MCP SET Part 1 for tolerances tested by ASTM E1155M or ASTM E1155. These requirements are based upon the latest FF/FL method. Floor slabs shall conform to the following ACI F-number requirements unless noted otherwise:

a. Slab on Grade:

Specified Overall Values - FF30/FL23 minimum
Minimum Local Values - FF17/FL15 minimum

b. Level Suspended Slabs Shored Until After Testing:

Specified Overall Values - FF25/FL20 minimum
Minimum Local Values - FF17/FL15 minimum

c. Unlevel Shored Suspended Slabs and Unshored Suspended Slabs:

Specified Overall Values - FF25
Minimum Local Values - FL17

Floor slabs subject to vehicular traffic or receiving thin-set flooring shall conform to the following ACI F-number requirements:

a. Slab on Grade:

Specified Overall Values - FF35/FL25 minimum
Minimum Local Values - FF25/FL17 minimum

b. Level Suspended Slabs Shored Until After Testing:

Specified Overall Values - FF30/FL20 minimum
Minimum Local Values - FF25/FL15 minimum

c. Unlevel Shored Suspended Slabs and Unshored Suspended Slabs:

Specified Overall Values - FF30
Minimum Local Values - FL25

3.4.3.4 Measurement of Floor Tolerances

Test floor slabs within 24 hours of the final troweling. Submit test results to Contracting Officer within 12 hours after collecting data. Floor flatness inspector shall provide a tolerance report which includes:

a. Name of Project

b. Name of Contractor

c. Date of Data Collection

d. Date of Tolerance Report

e. A Key Plan Showing Location of Data Collected

f. Results Required by ASTM E1155M ASTM E1155

3.4.3.5 Broom Finish

Screed and float the concrete to required finish plane with no coarse aggregate visible. After surface moisture disappears, broom or brush the surface with a broom or fiber bristle brush in a direction transverse to that of the main traffic or as directed.

3.4.3.6 Expansion and Contraction Joints

Make expansion and contraction joints in accordance with the details shown or as otherwise specified. Provide 13 mm (1/2 inch) thick transverse expansion joints where new work abuts an existing concrete. Provide expansion joints at a maximum spacing of 10 m (30 feet) on center in sidewalks and at a maximum spacing equal to 30 times the thickness of the slab , unless otherwise indicated. Provide contraction joints at a maximum spacing of 2 linear meters (6 linear feet) in sidewalks and at a maximum spacing equal to 30 times the thickness of the slab , unless otherwise indicated. Cut contraction joints at a minimum of 25 mm (1 inch) deep with a jointing tool after the surface has been finished.

3.5 CURING AND PROTECTION

Beginning immediately after placement, and continuing for at least 7 days, cure and protect all concrete from premature drying, extremes in temperature, rapid temperature change, freezing, mechanical damage, and exposure to rain or flowing water. Provide all materials and equipment needed for adequate curing and protection at the site of the placement prior to the start of concrete placement. Accomplish moisture preservation of moisture for concrete surfaces not in contact with forms by one of the following methods:

a. Continuous sprinkling or ponding.

b. Application of absorptive mats or fabrics kept continuously wet.

c. Application of sand kept continuously wet.

d. Application of impervious sheet material conforming to ASTM C171 or KS F 4007.

e. Application of membrane-forming curing compound conforming to ASTM C309, Type 1-D, or KS F 2540 on surfaces permanently exposed to view. Accomplish Type 2 on other surfaces in accordance with manufacturer's instructions.

Accomplish the preservation of moisture for concrete surfaces placed against wooden forms by keeping the forms continuously wet for 7 days . If forms are removed prior to end of the required curing period, use other curing methods for the balance of the curing period. Do not perform protection removal if the temperature of the air in contact with the concrete may drop more than 15 degrees C (60 degrees F) within a 24 hour period.

3.6 TESTS AND INSPECTIONS

3.6.1 Field Testing Technicians

The individuals who sample and test concrete, as required in this specification, shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.6.2 Inspection Details and Frequency of Testing

3.6.2.1 Preparations for Placing

Inspect foundation or construction joints, forms, and embedded items in sufficient time prior to each concrete placement by the Contractor to certify that it is ready to receive concrete.

3.6.2.2 Air Content

Check air content at least once during each shift that concrete is placed for each class of concrete required. Obtain samples in accordance with ASTM C172/C172M or KS F 2401 and tested in accordance with ASTM C231/C231M or KS F 2421.

3.6.2.3 Slump

Check slump once during each shift that concrete is produced for each class of concrete required. Obtain samples in accordance with ASTM C172/C172M or KS F 2401 and tested in accordance with ASTM C143/C143M or KS F 2402.

3.6.2.4 Consolidation and Protection

Ensure that the concrete is properly consolidated, finished, protected, and cured.

3.6.3 Action Required

3.6.3.1 Placing

Do not permit placing to begin until the availability of an adequate number of acceptable vibrators, which are in working order and have competent operators, has been verified. Do not continue placing if any pile is inadequately consolidated.

3.6.3.2 Air Content

Whenever an air content test result is outside the specification limits, adjust the dosage of the air-entrainment admixture prior to delivery of concrete to forms.

3.6.3.3 Slump

Whenever a slump test result is outside the specification limits, adjust the batch weights of water and fine aggregate prior to delivery of concrete to the forms. The adjustments are to be made so that the water-cement ratio does not exceed that specified in the submitted concrete mixture proportion.

3.6.4 Reports

Report the results of all tests and inspections conducted at the project site informally at the end of each shift. Submit written reports weekly. Deliver within 3 days after the end of each weekly reporting period.

3.7 FORM WORK

Form work shall conform to ACI MCP SET Parts 2 through 5.

3.7.1 Preparation of Form Surfaces

Forms shall be true to line and grade, mortar-tight, and sufficiently rigid to prevent objectionable deformation under load. Form surfaces for permanently exposed faces shall be smooth, free from irregularities, dents, sags, or holes. Chamfer exposed joints and exposed edges. Arrange internal ties so that when the forms are removed, the form ties are not less than 50 mm (2 inches) from concrete surfaces permanently exposed to view or exposed to water on the finished structure.

3.7.2 Form Coating

Coat forms, for exposed surfaces, with a nonstaining form release coating applied shortly before concrete is placed. Forms for unexposed surfaces may be wetted in lieu of coating immediately before the placing of concrete, except that in freezing weather form release coating shall be used.

3.7.3 Removal of Forms

Remove forms carefully to prevent damage to the concrete. Do not remove forms before the expiration of the minimum time indicated below:

Arches, beams and deck-type slabs	144 hours
Columns and walls (lifts 4.5 meter and under)	24 hours
Columns and walls (lifts over 4.5 meter)	48 hours
Columns and walls (lifts 15 feet and under)	24 hours
Columns and walls (lifts over 15 feet)	48 hours

3.8 STEEL REINFORCING

Reinforcement shall be free from loose, flaky rust and scale, and free from oil, grease, or other coating which might destroy or reduce the reinforcement's bond with the concrete.

3.8.1 Fabrication

Shop fabricate steel reinforcement in accordance with ACI MCP SET Parts 2 and 3. Shop details and bending shall be in accordance with ACI MCP SET Parts 2 and 3.

3.8.2 Splicing

Perform splices in accordance with ACI MCP SET Parts 2 and 3.

3.8.3 Supports

Secure reinforcement in place by the use of metal or concrete supports, spacers, or ties.

3.9 EMBEDDED ITEMS

Before placing concrete, take care to determine that all embedded items are firmly and securely fastened in place. Provide embedded items free of oil and other foreign matter, such as loose coatings of rust, paint and scale. Embedding of wood in concrete is permitted only when specifically authorized or directed.

3.10 CHEMICAL-HARDENER TREATMENT

Apply Liquid-Chemical Floor Hardener where indicated, after curing and drying concrete surface. Dilute liquid hardener with water and apply in three coats. First coat shall be one-third strength, second coat one-half strength, and third coat two-thirds strength. Apply each coat evenly and allow it to dry 24 hours before applying next coat. Apply proprietary chemical hardeners in accordance with manufacturer's printed directions.

3.11 FIELD TESTING

a. Provide samples and test concrete for quality control during placement. Sampling of fresh concrete for testing shall be in accordance with ASTM C172/C172M.

b. Test concrete for compressive strength at 7 and 28 days for each design mix. Concrete test specimens shall conform to ASTM C31/C31M. Perform Compressive strength testing conforming to ASTM C39/C39M.

c. Test Slump at the site of discharge for each design mix in accordance with ASTM C143/C143M.

d. Test air content for air-entrained concrete in accordance with ASTM C231/C231M. Test concrete using lightweight or extremely porous aggregates in accordance with ASTM C173/C173M.

e. Determine temperature of concrete at time of placement in accordance with ASTM C1064/C1064M.

-- End of Section --

SECTION 03 40 00.00 10

PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 211.2	(1998; R 2004) Standard Practice for Selecting Proportions for Structural Lightweight Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 318	(2011; Errata 2011) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011) Building Code Requirements for Structural Concrete & Commentary

AMERICAN CONCRETE PIPE ASSOCIATION (ACPA)

ACPA 01-102	(2000) Concrete Pipe Handbook
ACPA 01-110	(1984) Design Manual for Sulfide and Corrosion Prediction and Control
ACPA QPC	(2005; Ver 3.0) QCast Plant Certification Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel

	Hardware
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A496/A496M	(2007) Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A497/A497M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M	(2009b) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767/A767M	(2009) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A82/A82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A884/A884M	(2006) Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1107/C1107M	(2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2010a) Standard Specification for Fiber-Reinforced Concrete
ASTM C1240	(2011) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1244	(2005ae1) Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
ASTM C1244M	(2005ae1) Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to

	Backfill (Metric)
ASTM C138/C138M	(2013a) Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C1478	(2008) Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals
ASTM C1478M	(2008a) Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals (Metric)
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C173/C173M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M	(2014) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C330/C330M	(2009) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C443	(2011) Standard Specification for Joints

	for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C877	(2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C877M	(2002; R 2009) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections (Metric)
ASTM C891	(2011) Installation of Underground Precast Concrete Utility Structures
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C923	(2008) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C923M	(2008b) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)
ASTM C989/C989M	(2013) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C990	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)

CSA GROUP (CSA)

CSA A23.4	(2009; R 2014) Precast Concrete - Materials and Construction

NATIONAL PRECAST CONCRETE ASSOCIATION (NPCA)

NPCA QC Manual	(2005; R 2006) Quality Control Manual for Precast Plants

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2011) Steel Bars for Concrete Reinforcement
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS L 5201	(2013) Portland Cement
KS L 5508	(2007) Fly Ash and Other Pozzolans for Use with Lime

1.2 SYSTEM DESCRIPTION

Furnish precast concrete units designed and fabricated by an experienced and acceptable precast concrete manufacturer who has been, for at least 3 years, regularly and continuously engaged in the manufacture of precast concrete work similar to that indicated on the drawings. Coordinate precast work with the work of other trades.

1.2.1 Standard Precast Units

Design standard precast concrete units to withstand indicated design load conditions in accordance with applicable industry design standards. Design shall also consider stresses induced during handling, shipping and installation as to avoid product cracking or other handling damage. Indicate design loads for precast concrete units on the shop drawings. Submit drawings for standard precast concrete units furnished by the precast concrete producer for approval by the Contracting Officer. These drawings shall demonstrate that the applicable industry design standards have been met. Include installation and construction information on shop drawings. Include details of steel reinforcement size and placement as well as supporting design calculations, if appropriate. Produce precast concrete units in accordance with the approved drawings. Submit cut sheets, for standard precast concrete units, showing conformance to project drawings and requirements, and to applicable industry design standards listed in this specification.

1.2.2 Custom-Made Precast Units

Submit design calculations for custom-made precast units, prepared and sealed by a registered professional engineer, for approval prior to fabrication. Include in the calculations the analysis of units for lifting stresses and the sizing of lifting devices. Submit drawings furnished by the precast concrete producer for approval by the Contracting Officer. Show on these drawings complete design, installation, and construction information in such detail as to enable the Contracting Officer to determine the adequacy of the proposed units for the intended purpose. Include details of steel reinforcement size and placement as well as supporting design calculations, if appropriate. Produce precast concrete units in accordance with the approved drawings.

1.2.3 Proprietary Precast Units

Products manufactured under franchise arrangements shall conform to all the requirements specified by the franchiser. Items not included in the franchise specification, but included in this specification, shall conform to the requirements in this specification. Submit standard plans or informative literature, for proprietary precast concrete units. Make available supporting calculations and design details upon request. Provide sufficient information as to demonstrate that such products will perform the intended task.

1.2.4 Joints and Sealants

Provide joints and sealants between adjacent units of the type and configuration indicated on shop drawings meeting specified design and performance requirements.

1.2.5 Concrete Mix Design

1.2.5.1 Concrete Mix Proportions

Base selection of proportions for concrete on the methodology presented in ACI 211.1 for normal weight concrete and ACI 211.2 for lightweight concrete. Develop the concrete proportions using the same type and brand of cement, the same type and brand of pozzolan, the same type and gradation of aggregates, and the same type and brand of admixture that will be used in the manufacture of precast concrete units for the project. Do not use calcium chloride in precast concrete containing reinforcing steel or other embedded metal items. At a minimum of thirty days prior to precast concrete unit manufacturing, the precast concrete producer will submit a mix design and proportions for each strength and type of concrete that will be used. Furnish a complete list of materials, including quantity, type, brand and applicable data sheets for all mix design constituents as well as applicable reference specifications. The use of self-consolidating concrete is permitted, provided that mix design proportions and constituents meet the requirements of this specification.

1.2.5.2 Concrete Strength

Provide precast concrete units with a 28-day compressive strength (f'c) of 20.7 MPa (3,000 psi), or as indicated.

1.2.5.3 Water-to-Cement Ratio

Furnish concrete, that will be exposed to freezing and thawing, containing entrained air and with water-cement ratios of 0.45 or less. Furnish concrete which will not be exposed to freezing, but which is required to be watertight, with a water-cement ratio of 0.48 or less if the concrete is exposed to fresh water, or 0.45 or less if exposed to brackish water or sea water. Furnish reinforced concrete exposed to deicer salts, brackish water or seawater with a water-cement ratio of 0.40 or less for corrosion protection.

1.2.5.4 Air Content

The air content of concrete that will be exposed to freezing conditions shall be within the limits given below.

	AIR CONTENT PERCENT	
NOMINAL MAXIMUM AGGREGATE SIZE	SEVERE EXPOSURE	MODERATE EXPOSURE
10 mm (3/8 inch)	6.0 to 9.0	4.5 to 7.5
13 mm (1/2 inch)	5.5 to 8.5	4.0 to 7.0
19 mm (3/4 inch)	4.5 to 7.5	3.5 to 6.5
25 mm (1.0 inch)	4.5 to 7.5	3.0 to 6.0
38 mm (1.5 inch)	4.5 to 7.0	3.0 to 6.0
Note: For specified compressive strengths greater than 34.5 MPa (5000 psi), air content may be reduced 1 percent		

1.2.5.5 Corrosion Control for Sanitary Sewer Systems

Follow design recommendations outlined in Chapter 7 of ACPA 01-102 or the ACPA 01-110 when hydrogen sulfide is indicated as a potential problem.

1.3 SUBMITTALS

All submittals are the responsibility of the precast concrete producer. Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Procedures

SD-02 Shop Drawings

Standard Precast Units
Custom-Made Precast Units

SD-03 Product Data

Standard Precast Units
Proprietary Precast Units
Embedded Items
Accessories

SD-05 Design Data

Design Calculations
Concrete Mix Proportions

SD-06 Test Reports

Test Reports

1.4 QUALITY ASSURANCE

Demonstrate adherence to the standards set forth in NPCA QC Manual and/or ACPA QPC. Meet requirements written in the subparagraphs below.

1.4.1 Qualifications, Quality Control and Inspection

1.4.1.1 Qualifications

Select a precast concrete producer that has been in the business of producing precast concrete units similar to those specified for a minimum of 3 years. The precast concrete producer shall maintain a permanent quality control department or retain an independent testing agency on a continuing basis.

1.4.1.2 Quality Control Procedures

Submit quality control procedures established by the precast manufacturer in accordance with NPCA QC Manual and/or ACPA QPC. Show that the following QC tests are performed as required and in accordance with the ASTM standards indicated.

a. Slump: Perform a slump test for each 115 cubic m (150 cu yd) of concrete produced, or once a day, whichever comes first. Perform slump tests in accordance with ASTM C143/C143M.

b. Temperature: Measure the temperature of fresh concrete when slump or air content tests are made and when compressive test specimens are made in accordance with ASTM C1064/C1064M.

c. Compressive Strength: Make at least four compressive strength specimens for each 115 cubic m (150 cubic yards) of concrete of each mix in accordance with the following Standards: ASTM C31/C31M, ASTM C192/C192M, ASTM C39/C39M.

d. Air Content: Perform tests for air content on air-entrained, wet-cast concrete for each 115 cubic m (150 cu yd) of concrete, but not less often than once each day when air-entrained concrete is used. Determine the air content in accordance with either ASTM C231/C231M or ASTM C173/C173M for normal weight aggregates and ASTM C173/C173M for lightweight aggregates.

e. Unit Weight: Perform tests for unit weight a minimum of once per week to verify the yield of batch mixes. Perform unit weight tests for each 75 cubic m (100 cu yd) of lightweight concrete in accordance with ASTM C138/C138M.

1.4.1.3 Inspection

The Contracting Officer may place an inspector in the plant when the units covered by this specification are being manufactured. The burden of payment for plant inspection will be clearly detailed in the specification. The precast concrete producer shall give notice 14 days prior to the time the units will be available for plant inspection. Neither the exercise nor waiver of inspection at the plant will affect the Government's right to enforce contractual provisions after units are transported or erected.

1.4.1.4 Test Reports

Submit the following as specified in paragraph SUBMITTALS:

a. Material certifications and/or laboratory test reports, including mill tests and all other test data, for Portland Cement, blended cement, pozzolans, ground granulated blast furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

b. Test reports showing that the mix has been successfully tested to produce concrete with the properties specified and will be suitable for the job conditions. Such tests may include compressive strength, flexural strength, plastic or hardened air content, freeze thaw durability, abrasion and absorption. Clearly detail in the specifications special tests for precast concrete or cast-in items.

c. Sufficient documentation, when the use of self-consolidating concrete (SCC) is proposed, showing a minimum of 30-days production track records demonstrating that SCC is appropriate for casting of the product.

d. In-plant QA/QC inspection reports, upon the request of the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver precast units to the site in accordance with the delivery schedule to avoid excessive build-up of units in storage at the site. Upon delivery to the jobsite, all precast concrete units will be inspected by the Contracting Officer for quality and final acceptance.

1.5.2 Storage

Store units off the ground or in a manner that will minimize potential damage.

1.5.3 Handling

Handle, transport, and store products in a manner to minimize damage. Lifting devices or holes shall be consistent with industry standards. Perform lifting with methods or devices intended for this purpose as indicated on shop drawings.

PART 2 PRODUCTS

2.1 MATERIALS

Except as otherwise specified in the following paragraphs, conform material to Section 03 30 00 CAST-IN-PLACE CONCRETE and Section 03 20 00.00 10 CONCRETE REINFORCING.

2.1.1 Cement

Furnish cement conforming to ASTM C150/C150M, Type I, II, III or V, or KS L 5201. Furnish blended cements that conform to ASTM C595/C595M.

2.1.2 Silica Fume

Provide silica fume conforming to ASTM C1240. Provide available alkalis conforming to the optimal limit given in Table 2 of ASTM C1240. Silica fume may be furnished as a dry, densified material or as a slurry. When necessary, coordinate the services of a technical representative experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume.

2.1.3 Fly Ash and Pozzolans

Fly ash is required as a supplementary cementitious material (SCM) conforming to ASTM C618, Class C or F, or KS L 5508 with 4 percent maximum loss on ignition and 35 percent maximum cement replacement by weight.

2.1.4 Ground Granulated Blast-Furnace Slag

Ground granulated blast furnace slag may be used as a supplementary cementitious material conforming to ASTM C989/C989M, Grade 120 with between 25 to 50 percent maximum cement replacement by weight.

2.1.5 Water

Furnish water potable or free of deleterious substances in amounts harmful to concrete or embedded metals.

2.1.6 Aggregates

2.1.6.1 Selection

Furnish aggregates conforming to ASTM C33/C33M or KS F 2502. Provide aggregates not containing any substance, which may be deleteriously reactive with the alkalis in the cement.

2.1.6.2 Aggregates for Lightweight Concrete

ASTM C330/C330M

2.1.7 Admixtures

2.1.7.1 Air-Entraining

ASTM C260/C260M

2.1.7.2 Accelerating, Retarding, Water Reducing

ASTM C494/C494M

2.1.7.3 Pigments

Non-fading and lime-resistant

2.1.8 Reinforcement

2.1.8.1 Reinforcing Bars

a. Deformed Billet-steel: ASTM A615/A615M or KS D 3504
b. Deformed Low-alloy steel: ASTM A706/A706M or KS D 3504

2.1.8.2 Reinforcing Wire

a. Plain Wire: ASTM A82/A82M
b. Deformed Wire: ASTM A496/A496M

2.1.8.3 Welded Wire Fabric

a. Plain Wire: ASTM A185/A185M
b. Deformed Wire: ASTM A497/A497M

2.1.8.4 Epoxy Coated Reinforcement

a. Reinforcing Bars: ASTM A775/A775M
b. Wires and Fabric: ASTM A884/A884M

2.1.8.5 Galvanized Reinforcement

Provide galvanized reinforcement conforming to ASTM A767/A767M.

2.1.9 Synthetic Fiber Reinforcement

Synthetic fiber shall be polypropylene with a denier less than 100 and a nominal fiber length of 50 mm (2 inch).

2.1.10 Inserts and Embedded Metal

All items embedded in concrete shall be of the type required for the intended task, and meet the following standards.

a. Structural Steel Plates, Angles, etc.: ASTM A36/A36M
b. Hot-dipped Galvanized: ASTM A153/A153M
c. Proprietary Items: In accordance with manufacturers published literature

2.1.11 Accessories

Submit proper installation instructions and relevant product data for items including, but not limited to, sealants, gaskets, connectors, steps, cable racks and other items installed before or after delivery.

a. Rubber Gaskets for Circular Concrete Sewer Pipe and Culvert Pipe: ASTM C443M (ASTM C443).

b. External Sealing Bands for Noncircular Sewer, Storm Drain and Culvert Pipe: ASTM C877M (ASTM C877).

c. Preformed Flexible Joint Sealants for Concrete Pipe, Manholes, and Manufactured Box Sections: ASTM C990M (ASTM C990).

d. Elastomeric Joint Sealants: ASTM C920

2.1.12 Pipe Entry Connectors

Pipe entry connectors shall conform to ASTM C923M (ASTM C923) or ASTM C1478M (ASTM C1478).

2.1.13 Grout

Nonshrink Grout shall conform to ASTM C1107/C1107M. Cementitious grout shall be a mixture of portland cement, sand, and water. Proportion one part cement to approximately 2.5 parts sand, with the amount of water based on placement method.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 FABRICATION AND PLACEMENT

Perform fabrication in accordance with NPCA QC Manual and/or ACPA QPC unless specified otherwise.

3.1.1 Forms

Use forms, for manufacturing precast concrete products, of the type and design consistent with industry standards and practices. They should be capable of consistently providing uniform products and dimensions. Construct forms so that the forces and vibrations to which the forms will be subjected can cause no product damage. Clean forms of concrete build-up after each use. Apply form release agents according to the manufacturer's recommendations and do not allow concrete to build up on the form casting surfaces.

3.1.2 Reinforcement

Follow applicable ASTM Standard or ACI 318M (ACI 318) for placement and splicing. Fabricate cages of reinforcement either by tying the bars, wires or welded wire fabric into rigid assemblies or by welding, where permissible, in accordance with AWS D1.4/D1.4M. Position reinforcing as specified by the design and so that the concrete cover conforms to requirements. The tolerance on concrete cover shall be one-third of that specified but not more than 13 mm (1/2 inch). Provide concrete cover not less than 13 mm (1/2 inch). Take positive means to assure that the reinforcement does not move significantly during the casting operations.

3.1.3 Embedded Items

Position embedded items at locations specified in the design documents. Perform welding in accordance with AWS D1.1/D1.1M when necessary. Hold rigidly in place inserts, plates, weldments, lifting devices and other items to be imbedded in precast concrete products so that they do not move significantly during casting operations. Submit product data sheets and proper installation instruction for anchors, lifting inserts and other devices. Clearly indicate the products dimensions and safe working load.

3.1.4 Synthetic Fiber Reinforced Concrete

Add fiber reinforcement to the concrete mix in accordance with the applicable sections of ASTM C1116/C1116M and the recommendations of the manufacturer, and in an amount of 0.1 percent by volume.

3.2 CONCRETE

3.2.1 Concrete Mixing

Mixing operations shall produce batch-to-batch uniformity of strength, consistency, and appearance.

3.2.2 Concrete Placing

Deposit concrete into forms as near to its final location as practical. Keep the free fall of the concrete to a minimum. Consolidate concrete in such a manner that segregation of the concrete is minimized and honeycombed areas are kept to a minimum. Use vibrators to consolidate concrete with frequencies and amplitudes sufficient to produce well consolidated concrete.

3.2.2.1 Cold Weather Concreting

Perform cold weather concreting in accordance with ACI 306.1.

a. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather.

b. Free from frost all concrete materials and all reinforcement, forms, fillers, and ground with which concrete is to come in contact.

c. Do not use frozen materials or materials containing ice.

d. In cold weather the temperature of concrete at the time of placing shall not be below8 degrees C (45 degrees F). Discard concrete that freezes before its compressive strength reaches 3.45 MPa (500 psi).

3.2.2.2 Hot Weather Concreting

Recommendations for hot weather concreting are given in detail in ACI 305R. During hot weather, give proper attention to constituents, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure. The temperature of concrete at the time of placing shall not exceed 32 degrees C (90 degrees F).

3.2.3 Concrete Curing

Commence curing immediately following the initial set and completion of surface finishing.

3.2.3.1 Curing by Moisture Retention

Prevent moisture evaporation from exposed surfaces until adequate strength for stripping is reached by one of the following methods:

a. Cover with polyethylene sheets a minimum of 0.15 mm (6 mils) thick in accordance with ASTM C171.

b. Cover with burlap or other absorptive material and keep continually moist.

c. Use of a membrane-curing compound applied at a rate not to exceed 19 square m/4L (200 square ft/gallon), or in accordance with manufacturers' recommendations according to ASTM C309.

3.2.3.2 Curing with Heat and Moisture

Do not subject concrete to steam or hot air until after the concrete has attained its initial set. Apply steam, if used, within a suitable enclosure, which permits free circulation of the steam in accordance with CSA A23.4. If hot air is used for curing, take precautions to prevent moisture loss from the concrete. The temperature of the concrete shall not be permitted to exceed 65 degrees C (150 degrees F). These requirements do not apply to products cured with steam under pressure in an autoclave.

3.2.4 Surface Finish

Finish unformed surfaces of wet-cast precast concrete products as specified. If no finishing procedure is specified, finish such surfaces using a strike-off to level the concrete with the top of the form.

3.2.4.1 Formed Non-Architectural Surfaces

Cast surfaces against approved forms following industry practices in cleaning forms, designing concrete mixes, placing and curing concrete. Normal color variations, form joint marks, small surface holes caused by air bubbles, and minor chips and spalls will be accepted but no major imperfections, honeycombs or other major defects will be permitted.

3.2.4.2 Unformed Surfaces

Finish unformed surfaces with a vibrating screed, or by hand with a float. Normal color variations, minor indentations, minor chips and spalls will be accepted but no major imperfections, honeycombs, or other major defects shall be permitted.

3.2.4.3 Special Finishes

Troweled, broom or other finishes shall be according to the requirements of project documents and performed in accordance with industry standards or supplier specifications. Submit finishes for approval when required by the project documents. The sample finishes shall be approved prior to the start of production.

3.2.5 Stripping Products from Forms

Do not remove products from the forms until the concrete reaches the compressive strength for stripping required by the design. If no such requirement exists, products may be removed from the forms after the final set of concrete provided that stripping damage is minimal.

3.2.6 Patching and Repair

No repair is required to formed surfaces that are relatively free of air voids and honeycombed areas, unless the surfaces are required by the design to be finished.

3.2.6.1 Repairing Minor Defects

Defects that will not impair the functional use or expected life of a precast concrete product may be repaired by any method that does not impair the product.

3.2.6.2 Repairing Honeycombed Areas

When honeycombed areas are to be repaired, remove all loose material and cut back the areas into essentially horizontal or vertical planes to a depth at which coarse aggregate particles break under chipping rather than being dislodged. Use proprietary repair materials in accordance with the manufacturer's instructions. If a proprietary repair material is not used, saturate the area with water. Immediately prior to repair, the area should be damp, but free of excess water. Apply a cement-sand grout or an approved bonding agent to the chipped surfaces, followed immediately by consolidating an appropriate repair material into the cavity.

3.2.6.3 Repairing Major Defects

Evaluate, by qualified personnel, defects in precast concrete products which impair the functional use or the expected life of products to determine if repairs are feasible and, if so, to establish the repair procedure.

3.2.7 Shipping Products

Do not ship products until they are at least 5 days old, unless it can be shown that the concrete strength has reached at least 75 percent of the specified 28-day strength, or that damage will not result, impairing the performance of the product.

3.3 INSTALLATION

3.3.1 Site Access

It is the Contractor's responsibility to provide adequate access to the site to facilitate hauling, storage and proper handling of the precast concrete products.

3.3.2 General Requirements

a. Install precast concrete products to the lines and grades shown in the contract documents or otherwise specified.

b. Lift products by suitable lifting devices at points provided by the precast concrete producer.

c. Install products in accordance with the precast concrete producer's instructions. In the absence of such instructions, install underground utility structures in accordance with ASTM C891. Install pipe and manhole sections in accordance with the procedures outlined by the American Concrete Pipe Association.

d. Field modifications to the product will relieve the precast producer of liability even if such modifications result in the failure of the product.

3.3.3 Water Tightness

Where water tightness is a necessary performance characteristic of the precast concrete product's end use, watertight joints, connectors and inserts should be used to ensure the integrity of the entire system.

3.4 FIELD QUALITY CONTROL

3.4.1 Site Tests

When water tightness testing is required for an underground product, use one of the following methods:

3.4.2 Vacuum Testing

Prior to backfill vacuum test system according to ASTM C1244M (ASTM C1244).

3.4.3 Water Testing

Perform water testing according to the contract documents and precast concrete producer's recommendations.

-- End of Section --

SECTION 03 41 16.08

PRECAST CONCRETE SLABS (MAX. SPAN 8'- 0" O.C.)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI C-21	(1992) Elevated Slabs

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA BOOK	(2012) AWPA Book of Standards

ASME INTERNATIONAL (ASME)

ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.2.6	(2010) Fasteners for Use in Structural Applications
ASME B18.21.1	(2009) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)
ASME B18.22M	(1981; R 2010) Metric Plain Washers
ASME B18.6.3	(2010) Machine Screws, Tapping Screws, and Machine Drive Screws (Inch Series)
ASME B18.6.7M	(1999; R 2010) Metric Machine Screws

ASTM INTERNATIONAL (ASTM)

ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates

ASTM C387/C387M	(2011b) Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
ASTM C514	(2004e1; R 2009) Standard Specification for Nails for the Application of Gypsum Board
ASTM D312	(2000; R 2006) Standard Specification for Asphalt Used in Roofing

KOREAN INDUSTRIAL STANDARDS (KS)

KS L 5201	(2013) Portland Cement

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS UU-B-790	(Rev A; Am 1; Notice 1) Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G
Installation Drawings; G

SD-03 Product Data

Precast Curb Units
Absorption CoverMoisture-Retaining Cover
Cement Grout Joint Sealing Materials

SD-05 Design Data

Design analysis
Calculations

SD-06 Test Reports

Nail Driving and Nail Pulling Tests
Strength Tests; G

SD-07 Certificates

Precast Concrete Roof Slabs; G
Precast Curb Units; G
Cement Grout Joint Sealing Materials

SD-08 Manufacturer's Instructions

Installation Instructions

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit fabrication drawings for precast concrete deck units. On the drawings, provide dimensions, size, and number of openings to be cut.

Provide and submit installation drawings for precast concrete roof slabs and cast-in-place curb units. On the drawings, provide details and layouts indicating structural framing, location and length of concrete slabs corresponding with the sequence and procedure to be followed in placing and fastening roof slabs, and location and type of fasteners. Ensure that drawings also show details of curb units indicating location of cants, crickets, drainage saddles, and other sloping surfaces.

2.2 COMPONENTS

2.2.1 Clips and Nails

Use zinc- or cadmium-plated steel strip clips, not less than 0.76 millimeter (0.0299-inch) thick (manufacturer's standard 0.76 millimeter (22-gage)). Ensure clips are formed to fit the top flange of steel beam purlins or steel joists having steel angle top chords, and of design recommended by the precast concrete roof slab manufacturer.

Use roofing nails that are 32 millimeter (1-1/4-inches) long, galvanized steel, conforming to ASTM C514, Type II, Style 20.

Submit manufacturer's catalog product data for clips and nails.

Submit certificates of compliance for clips and nails showing conformance with referenced standards contained in this section.

2.2.2 Threaded Fasteners

Provide fasteners that consist of machine screws, nuts, and washers.

Use slotted, flathead, galvanized, carbon steel machine screws conforming toASME B18.6.7M (ASME B18.6.3), Type I, Style 2s.

Use hexagon, galvanized, carbon steel nuts conforming to ASME B18.2.6 ASME B18.2.2, Type II, Style 10.

Provide round-type, galvanized, carbon steel, general-purpose assembly washers conforming to ASME B18.22M (ASME B18.21.1), Type A, Grade I, Class A.

Submit manufacturer's catalog product data for threaded fasteners.

Submit certificates of compliance for threaded fasteners showing conformance with referenced standards contained in this section.

2.3 MATERIALS

2.3.1 Precast Concrete Roof Slabs

Provide installation instructions that indicate the manufacturer's recommended installation methods and sequence.

Provide manufacturer's catalog data for all accessories including nails, threaded fasteners, and joint sealing compounds.

Submit design analysis and calculations for precast concrete roof slabs.

Submit certificates of compliance for precast concrete roof slabs showing conformance with referenced standards contained in this section.

Submit test reports for precast concrete roof slabs regarding nail driving and nail pulling tests and strength tests in accordance with ACI C-21.

Ensure roof slabs are flat or plank-shaped and conform to ACI C-21, Type I or Type II, with the following modifications:

a. Ensure flat slabs have wire mesh reinforcing in both top and bottom of the slab.

b. Slabs have nailing edges.

c. Ensure flat slabs have tongue-and-groove edges on sides and square edges on ends, except that edges for exposed roof sides are square.

d. Ensure flat slabs have tongue-and-groove edges on sides and ends, except that edges for exposed roof sides and ends are square.

Use channel shaped precast concrete roof slabs conforming to ACI C-21, Type I or Type II, with the following modifications:

a. Reinforce channel slabs with steel-wire mesh in the web section and one 12.7 millimeter (No. 4) steel reinforcing bar in each flange.

b. Ensure slabs have nailing edges.

c. Ensure that roof slabs, not suitable for nailing, have wood inserts. Pressure treat wood using a water-borne preservative and attain the minimum net retention of the solid preservative for lumber used in protected locations, in accordance with AWPA BOOK. Ensure that inserts are at least 25 by 75 millimeter (1 by 3 inches) in section, placed in rows on 600 millimeter (24 inches) on center, and parallel with the roof slope. Ensure inserts are set flush with surfaces of slabs and rigidly secured in place with anchors designed and spaced to provide the holding strength required for subsequent nailing of roofing.

2.3.2 Precast Curb Units

Construct curb units of the same material, reinforce for same strength requirements as precast concrete roof slabs. Design precast curb units to fit securely in the anchorage provided by structural framing members.

Submit manufacturer's catalog data for all accessories including nails, threaded fasteners, and joint sealing compounds.

Submit certificates of compliance for precast curb units showing conformance with referenced standards contained in this section.

2.3.3 Cement Grout Joint Sealing Materials

Provide portland cement that conforms to ASTM C150/C150M, Type I or KS L 5201.

Ensure that aggregate for cement grout is clean, sharp, uniformly graded, natural or manufactured sand conforming to ASTM C33/C33M.

Submit manufacturer's catalog product data for cement grout joint sealing materials.

Submit certificates of compliance for precast curb units showing conformance with referenced standards contained in this section.

2.3.4 Bituminous Joint Sealing Materials

Provide bituminous cement that is steep asphalt for use in constructing built-up roof coverings conforming to ASTM D312, Type IV.

Compose joint-sealing tape of two layers of uncreped kraft paper united by steep asphalt with approximately 13 by 8 millimeter (1/2- by 1/3-inch) glass-fiber reinforcement embedded in the asphalt laminate. Tape to meet requirements of FS UU-B-790, Type I, Grade C, Style 4, with the following modifications:

a. Ensure that width is 150 millimeter (6 inches).

b. Dry tensile strength cannot be less than 6150 newtons per meter (35 pounds per inch) width, both directions.

Submit manufacturer's catalog product data for bituminous joint sealing materials.

Submit certificates of compliance for bituminous joint sealing materials showing conformance with referenced standards contained in this section.

2.3.5 Packaged Concrete Materials

Ensure that concrete materials are packaged, dry, combined materials for concrete conforming to ASTM C387/C387M, lightweight concrete (using natural sand), and have the following properties:

Property	**Value**
Compressive strength at 28 days	Not less than 20 Megapascal
Maximum aggregate size	9.5 millimeters
Slump	Not more than 75 millimeters
Total air content by volume	Not less than 6 nor more than 10 percent

Property	**Value**
Compressive strength at 28 days	Not less than 3,000 psi

Property	**Value**
Maximum aggregate size	3/8 inch
Slump	Not more than 3 inches
Total air content by volume	Not less than 6 nor more than 10 percent

Provide manufacturer's catalog product data for packaged concrete materials.

2.3.6 Water For Mixing Cement Grout And Concrete

Use potable water for mixing cement grout and concrete.

2.3.7 Concrete Curing Materials

Ensure the absorption cover for curing concrete is burlap cloth made from jute or kenaf, conforming to AASHTO M 182, Class 3.

Ensure the moisture-retaining cover for curing concrete is white waterproof paper or white opaque polyethylene sheet conforming to ASTM C171.

Provide manufacturer's catalog product data for absorption covers and moisture-retaining covers.

2.4 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

Install precast roof slabs and accessories in accordance with the approved drawings and as specified.

3.1 PREPARATION

Ensure the supporting walls, purlins or joists, and other supporting members are in place before the placing of precast roof slabs is started. Do not place roof slabs during, or while there is a threat of, rain or snow.

3.1.1 Concrete Roof Slab Placement

Place each roof slab on structural framework to bear on at least two structural framing members. Ensure that end bearing is not less than 50 millimeter (2 inches). For roof slabs having square edges, ensure the ends occur over a structural framing member. Where installation requires cutting roof slabs, ensure the cut ends occur over supports at the wall or at openings. Cut roof slabs as specified.

Ends of roof slabs having tongue-and-groove edges on ends do not need to occur over a structural framing member; stagger such end joints in adjacent rows.

Align roof slabs in each row end to end, with adjacent rows parallel. Alignment does not depend on adjacent walls or structural framing members being accurately square.

3.2 INSTALLATION

3.2.1 Fastening Roof Slabs

Fasten roof slabs to each structural framework member by means of clips and nails. Where possible, alternate clips in position so that each clip is facing in the opposite direction of the next clip. Secure clips to roof slabs with one nail per clip and fit to the top flange or chord of structural framework member by slots in the clips formed for this purpose.

When the roof slope is greater than a 1 to 4 ratio, fasten roof slabs to supporting members by threaded fasteners in addition to the clips specified. Ensure that threaded fasteners are not less than 13 millimeter (1/2 inch) in diameter. Use countersunk fastener heads. Attach fasteners to the top flange or chord of supporting members by means of offset clips or other approved method. Ensure that threaded fasteners are not less than one fastener per 3 square meter (30 square feet) of roof area.

3.2.2 Cutting And Fitting

Perform roof slab cutting and fitting as required for passage of other work projecting through or adjacent to the roof decking. Ensure the cuts are straight and clean through roof slabs and at 90 degrees to severed surfaces without breaking, spalling, or appreciable crumbling at edges.

3.2.3 Sealing Joints

After roof slabs have been placed and fastened, seal the top portion of joints as specified.

Fill joints at ridges and hips and tongue-and-groove joints with cement grout. Provide cement grout that consists of portland cement, sand, and water mixed to manufactures instructions. Place grout so as to be even with the top surface of roof slabs. Remove excess grout and give grout surface a smooth finish.

Seal other joints with specified bituminous joint sealing materials. Center joint sealing tape over the joint and embedded in hot bituminous cement applied at the rate of 6 to 8 kilogram per 10 square meter (15 to 20 pounds per 100 square feet) of joint sealing tape. Provide end laps that are less than 100 millimeter (4 inches). Remove excess bitumen and ensure that the joint sealing tape surface is smooth and free of wrinkles.

3.2.4 Installation Of Precast Curb Units

Install precast curb units in accordance with approved drawings.

3.2.5 Fill For Sloping Surfaces

Ensure that fill for curb cants and other sloping surfaces consists of the specified packaged concrete materials mixed with water.

Mix concrete either manually or by mechanical mixer, using the quantity of water indicated on packaged concrete materials. Accurately measure water used in manual mixing. Equip mechanical mixer with a device to measure and control the amount of water used. Keep mixer drums, mixing boxes, tools, and other mixing equipment clean and free from hardened lumps of concrete.

Handle concrete mixture from the point of mixing and transferred to concrete conveying equipment and to locations of final deposit as rapidly as possible by methods that prevent segregation and loss of concrete mix materials. Ensure that mechanical equipment for conveying concrete mixtures is of such size and design as to ensure a uniform, continuous flow of concrete mixture at the delivery end. For concrete conveying equipment, maintain the inner surfaces free of hardened concrete, debris, water, snow, ice, or other deleterious materials.

Place and screed concrete mixture in a continuous operation until placing a section is completed. Ensure the finished surface is free of humps or hollows; sloped to drains; uniform, smooth, even plane; and of granular texture.

Immediately following the concrete finishing operation, ensure the concrete is kept continuously moist for at least 72 hours by covering the concrete surface with a specified absorptive cover for curing concrete, or kept continuously wet, by covering concrete surface with a specified moisture-retaining cover for curing concrete, or by a combination of both curing methods.

During the concrete curing period, protect concrete from damage caused by rain or running water, by excessively cold or hot temperatures, and from damaging mechanical disturbances.

3.3 COLD-WEATHER LIMITATIONS

Ensure that sealing joints, concrete mixing, or placing is not performed when the ambient temperature is 5 degrees C (40 degrees F) or below.

3.4 ADJUSTING AND CLEANING

Upon completion of roof decking work, sweep roof surfaces clean of debris and other foreign matter and left ready to receive roofing.

3.5 PROTECTION

Protect finished roof decking from damage by weather and construction operations until roofing is installed.

-- End of Section --

SECTION 04 20 00

MASONRY

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318	(2011; Errata 2011) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011) Building Code Requirements for Structural Concrete & Commentary
ACI 530/530.1	(2011; Errata 2011) Building Code Requirements and Specification for Masonry Structures and Related Commentaries
ACI SP-66	(2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A641/A641M	(2009a; R 2014) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A82/A82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM B370	(2012) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM C1019	(2011) Standard Test Method for Sampling and Testing Grout
ASTM C1072	(2011) Standard Test Method for Measurement of Masonry Flexural Bond

	Strength
ASTM C1142	(1995; R 2007) Standard Specification for Extended Life Mortar for Unit Masonry
ASTM C129	(2011) Standard Specification for Nonloadbearing Concrete Masonry Units
ASTM C140	(2012a) Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C144	(2011) Standard Specification for Aggregate for Masonry Mortar
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C207	(2006; R 2011) Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C216	(2011) Facing Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C270	(2012) Standard Specification for Mortar for Unit Masonry
ASTM C315	(2004; R 2012) Clay Flue Linings
ASTM C476	(2010) Standard Specification for Grout for Masonry
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C55	(2011) Concrete Brick
ASTM C593	(2006; R 2011) Fly Ash and Other Pozzolans for Use with Lime for Soil Stabilization
ASTM C62	(2010) Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C641	(2009) Staining Materials in Lightweight Concrete Aggregates
ASTM C652	(2011) Hollow Brick (Hollow Masonry Units Made from Clay or Shale)
ASTM C67	(2014) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C73	(2010) Calcium Silicate Brick (Sand-Lime Brick)
ASTM C780	(2011) Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

ASTM C90	(2011b) Loadbearing Concrete Masonry Units
ASTM C91/C91M	(2012) Standard Specification for Masonry Cement
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2287	(2011) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM E119	(2012a) Standard Test Methods for Fire Tests of Building Construction and Materials

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2012) International Building Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3552	(2008) Low Carbon Steel Wires
KS D 8308	(2001) Zinc Hot Dip Galvanizings
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 4002	(2008) Hollow Concrete Blocks
KS F 4004	(2008) Concrete Bricks
KS F 4009	(2011) Ready-Mixed Concrete
KS L 4201	(2008) Clay Brick
KS L 5201	(2013) Portland Cement
KS L 5219	(2007) Masonry Cement
KS L 5220	(2007) Dry Ready Mixed Cement Mortar
KS M 3501	(2004) Plastics..Unsaturated poly(vinyl chloride) sheets-Types, dimensions and characteristics-Part 1 : Sheets of thickness not less than 1 mm

1.2 SYSTEM DESCRIPTION

1.2.1 Design Requirements

1.2.1.1 Unit Strength Method

Compute compressive strength of masonry system "Unit Strength Method", ACI 530/530.1. Submit calculations and certifications of unit and mortar strength.

1.2.1.2 Seismic Requirement

In addition to design requirements of ICC IBC, provide additional seismic reinforcement in accordance with UFC 3-310-04. The total minimum reinforcing percentage for structural walls shall be 0.20 percent and non-structural walls shall be 0.15 percent. The maximum spacing of reinforcing bars shall be as follows:

Wall Type	Vertical	Horizontal
Structural	0.609 m (24 inches)	1.219 m (48 inches)
Non-structural	1.219 m (48 inches)	2.032 m (80 inches)

Bond beams are required at the top of footings, at the bottom and top of openings at roof and floor levels, and at the top of parapet walls.

1.2.1.3 Special Inspection

Perform special inspections and testing for seismic-resisting systems and components in accordance with UFC 3-310-04 SEISMIC DESIGN FOR BUILDINGS.

1.2.1.4 Masonry Strength

Determine masonry strength in accordance with ACI 530/530.1; submit test reports on three prisms as specified in ACI 530/530.1. The cost of testing shall be paid by the Contractor.

1.2.2 Additional Requirements

a. Maintain at least one spare vibrator on site at all times.

b. Provide bracing and scaffolding necessary for masonry work. Design bracing to resist wind pressure as required by local code.

1.2.3 Metrication

The Contractor has the option to use either hard metric or substitute inch-pound (soft-metric) CMU products. If the Contractor decides to substitute inch-pound CMU products, meet the following additional requirements:

a. The metric dimensions indicated on the drawings shall not be altered to accommodate inch-pound CMU products either horizontally or vertically. The 100 mm building module shall be maintained, except for the CMU products themselves.

b. Mortar joint widths shall be maintained as specified.

c. Rebars shall not be cut, bent or eliminated to fit into the inch-pound CMU products module.

d. Brick and inch-pound CMU products shall not be reduced in size by more than one-third (1/3) in height and one-half (1/2) in length. Cut CMU products shall not be located at ends of walls, corners, and other openings.

e. Cut, exposed brick and CMU products shall be held to a minimum and located where they would have the least impact on the architectural aesthetic goals of the facility.

f. Other building components, built into the CMU products, such as window frames, door frames, louvers, grilles, fire dampers, etc., that are required to be metric, shall remain metric.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Concrete Masonry Units (CMU)
Concrete Brick; G
Clay or Shale Brick; G
Cement; G
Cold Weather Installation; G
Precast Concrete Items; G
Fire-rated CMU; G

SD-05 Design Data

Pre-mixed Mortar
Unit Strength Method

SD-06 Test Reports

Efflorescence Test
Field Testing of Mortar
Field Testing of Grout
Prism tests; G

SD-07 Certificates

Masonry Inspector Qualifications; G

1.4 QUALITY ASSURANCE

1.4.1 Appearance

Manufacture bricks at one time and from the same batch. Blend all brick to produce a uniform appearance when installed. An observable "banding" or "layering" of colors or textures caused by improperly mixed brick is unacceptable.

1.4.2 Contamination

When using bricks containing contaminated soil, supplier shall certify that the hazardous waste is neutralized by the manufacturing process and that no additional pollutants will be released, or that the product is free from hazardous contaminants.

1.4.3 Masonry Inspector Qualifications

A qualified masonry inspector approved by the Contracting Officer shall perform inspection of the masonry work. Minimum qualifications for the masonry inspector shall be 5 years of reinforced masonry inspection experience or acceptance by a State, municipality, or other governmental body having a program of examining and certifying inspectors for reinforced masonry construction. The masonry inspector shall be present during preparation of masonry prisms, sampling and placing of masonry units, placement of reinforcement (including placement of dowels in footings and foundation walls), inspection of grout space, immediately prior to closing of cleanouts, and during grouting operations. The masonry inspector shall assure compliance with the drawings and specifications. The masonry inspector shall keep a complete record of all inspections and shall submit daily written reports to the Quality Control Supervisory Representative reporting the quality of masonry construction. Submit copies of masonry inspector reports.

1.4.4 Detail Drawings

Submit detail drawings showing bar splice locations. If the Contractor opts to furnish inch-pound CMU products, drawings showing elevation of walls exposed to view and indicating the location of all cut CMU products shall be submitted for approval.. Bent bars shall be identified on a bending diagram and shall be referenced and located on the drawings. Wall dimensions, bar clearances, and wall openings greater than one masonry unit in area shall be shown. No approval will be given to the shop drawings until the Contractor certifies that all openings, including those for mechanical and electrical service, are shown. If, during construction, additional masonry openings are required, the approved shop drawings shall be resubmitted with the additional openings shown along with the proposed changes. Location of these additional openings shall be clearly highlighted. The minimum scale for wall elevations shall be 1 to 50 (1/4 inch per foot). Reinforcement bending details shall conform to the requirements of ACI SP-66. Submit drawings including plans, elevations, and details of wall reinforcement; details of reinforcing bars at corners and wall intersections; offsets; tops, bottoms, and ends of walls; control and expansion joints; lintels; and wall openings.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered, stored, handled, and protected to avoid chipping, breakage, and contact with soil or contaminating material.

Store and prepare materials in already disturbed areas to minimize project site disturbance and size of project site.

1.5.1 Masonry Units

Cover and protect concrete masonry units and cementitious materials from precipitation. Conform to all handling and storage requirements of ASTM C90. Mark prefabricated lintels on top sides to show either the lintel schedule number or the number and size of top and bottom bars.

1.5.2 Reinforcement, Anchors, and Ties

Steel reinforcing bars, coated anchors, ties, and joint reinforcement shall be stored above the ground. Steel reinforcing bars and uncoated ties shall be free of loose mill scale and rust.

1.5.3 Cementitious Materials, Sand and Aggregates

Cementitious and other packaged materials shall be delivered in unopened containers, plainly marked and labeled with manufacturers' names and brands. Cementitious material shall be stored in dry, weathertight enclosures or be completely covered. Cement shall be handled in a manner that will prevent the inclusion of foreign materials and damage by water or dampness. Store sand and aggregates in a manner to prevent contamination or segregation.

1.6 PROJECT/SITE CONDITIONS

Conform to ACI 530/530.1 for hot and cold weather masonry erection.

1.6.1 Hot Weather Installation

Take the following precautions if masonry is erected when the ambient air temperature is more than 37 degrees C (99 degrees F) in the shade and the relative humidity is less than 50 percent or the ambient air temperature exceeds 32 degrees C (90 degrees F) and the wind velocity is more than 13 km/h (8 mph). All masonry materials shall be shaded from direct sunlight; mortar beds shall be spread no more than 1.2 m (4 feet) ahead of masonry; masonry units shall be set within one minute of spreading mortar; and after erection, masonry shall be protected from direct exposure to wind and sun for 48 hours.

1.6.2 Cold Weather Installation

Before erecting masonry when ambient temperature or mean daily air temperature falls below 4 degrees C (40 degrees F) or temperature of masonry units is below 4 degrees C (40 degrees F), submit a written statement of proposed cold weather construction procedures for approval.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

The source of materials which will affect the appearance of the finished work shall not be changed after the work has started except with Contracting Officer's approval. Submit sample of colored mortar with applicable masonry unit and color samples of three stretcher units and one unit for each type of special shape. Units shall show the full range of color and texture. Submit test reports from an approved independent laboratory. Test reports on a previously tested material shall be certified as the same as that proposed for use in this project. Submit certificates of compliance stating that the materials meet the specified requirements.

2.2 CLAY OR SHALE BRICK

Color range and texture of clay or shale brick shall be as indicated and shall conform to the approved sample. Brick shall conform to ASTM C62 or KS L 4201; Grade SW shall be used for brick in contact with earth or grade and for all exterior work and for all nonvertical surfaces. Grade SW or MW shall be used in other brickwork. Average dimensions of brick shall be 90 mm (3-5/8 inches) thick, 57 mm (2-1/4 inches) high, and 190 mm (8 inches) long (standard) or 100 mm (4 inches) thick, 68 mm (2-2/3 inches) high, and 200 mm (8 inches) long (nominal), subject to the tolerances specified in ASTM C62. Brick shall be tested for efflorescence. Clay or shale brick units shall be delivered factory-blended to provide a uniform appearance and color range in the completed wall.

2.2.1 Solid Clay or Shale Brick

Solid clay or shale brick shall conform to ASTM C62 or KS L 4201. Brick size shall be modular and the nominal size of the brick used shall be 92 mm (3-5/8 inches) thick, 57 mm (2-1/4 inches) high, and 200 mm (8 inches) long (nominal) or 100 mm (4 inches) thick, 68 mm (2-2/3 inches) high, and 200 mm (8 inches) (nominal). Minimum compressive strength of the brick shall be shall be as indicated on contract drawings.

2.2.2 Hollow Clay or Shale Brick

Hollow clay or shale brick shall conform to ASTM C652, Type HBS, HBX, HBA, HBB or KS L 4201. Brick size shall be modular and the nominal size of the brick used shall be as shown on the drawings. Where vertical reinforcement is shown in hollow brick, the minimum cell dimension shall be 64 mm (2-1/2 inches) and the units shall be designed to provide precise vertical alignment of the cells. Minimum compressive strength of the brick shall be shall be as indicated on contract drawings.

2.2.3 Sand-Lime Brick

ASTM C73, Grade SW, approximately 92 mm (3 5/8 inches) thick, 57 mm (2 1/4 inches) high, and 200 mm (8 inches) long (nominal), or nominal modular, with smooth surfaces and natural color.

2.2.4 Closure or Utility Brick

ASTM C216, Grade SW, Type FBS, 92 mm (3 5/8 inches) thick, 92 mm (3 5/8 inches) high, and 200 mm (8 inches) long (closure) or nominally 100 mm (4 inches) thick, 100 mm (4 inches) high, and 305 mm (12 inches) long (utility). Closure or utility brick may be used at the option of the Contractor, provided that changes necessitated by the use of such brick shall be the responsibility of the Contractor. Color, texture, and range of brick shall match the brick indicated.

2.3 CONCRETE BRICK

Concrete brick shall conform to ASTM C55, Grade N, or KS F 4004. Concrete brick may be used where necessary for filling out in concrete masonry unit construction. Submit samples as specified.

2.4 CONCRETE MASONRY UNITS (CMU)

Cement shall have a low alkali content and be of one brand. Units shall be of modular dimensions and air, water, or steam cured. Surfaces of units which are to be plastered or stuccoed shall be sufficiently rough to provide bond; elsewhere, exposed surfaces of units shall be smooth and of uniform texture. Exterior concrete masonry units shall have water-repellant admixture added during manufacture.

a. Hollow Load-Bearing Units: ASTM C90 or KS F 4002, made with lightweight or normal weight aggregate. Provide load-bearing units for exterior walls, foundation walls, load-bearing walls, and shear walls.

b. Hollow Non-Load-Bearing Units: ASTM C129, made with lightweight or normal weight aggregate. Load-bearing units may be provided in lieu of non-load-bearing units.

c. Solid Load-Bearing Units: ASTM C90 or KS F 4002, lightweight or normal weight units. Provide solid units for masonry bearing under structural framing members or as indicated.

2.4.1 Aggregates

Lightweight aggregates and blends of lightweight and heavier aggregates in proportions used in producing the units, shall comply with the following requirements when tested for stain-producing iron compounds in accordance with ASTM C641: by visual classification method, the iron stain deposited on the filter paper shall not exceed the "light stain" classification.

2.4.2 Kinds and Shapes

Units shall be modular in size and shall include closer, jamb, header, lintel, and bond beam units and special shapes and sizes to complete the work as indicated. In exposed interior masonry surfaces, units having a bullnose shall be used for vertical external corners except at door, window, and louver jambs. Radius of the bullnose shall be 25 mm (1 inch). Units used in exposed masonry surfaces in any one building shall have a uniform fine to medium texture and a uniform color.

2.4.3 Fire-Rated CMU

Concrete masonry units used in fire-rated construction shown on the drawings shall be of minimum equivalent thickness for the fire rating indicated and the corresponding type of aggregates indicated in TABLE I. Units containing more than one of the aggregates listed in TABLE I will be rated on the aggregate requiring the greater minimum equivalent thickness to produce the required fire rating. Construction shall conform to ASTM E119.

TABLE I FIRE-RATED CONCRETE MASONRY UNITS	
	Minimum equivalent thickness in mm (inches) for fire rating of:

TABLE I

FIRE-RATED CONCRETE MASONRY UNITS

Aggregate Type	4 hours	3 hours	2 hours
Pumice	120 (4.7)	100 (4.0)	75 (3.0)
Expanded slag	130 (5.0)	110 (4.2)	85 (3.3)
Expanded clay, shale, or slate	145 (5.7)	120 (4.8)	95 (3.7)
Limestone, scoria, cinders or unexpanded slag	150 (5.9)	130 (5.0)	100 (4.0)
Calcareous gravel	160 (6.2)	135 (5.3)	105 (4.2)
Siliceous gravel	170 (6.7)	145 (5.7)	115 (4.5)

Minimum equivalent thickness shall equal net volume as determined in conformance with ASTM C140 divided by the product of the actual length and height of the face shell of the unit in mm (inches). Where walls are to receive plaster or be faced with brick, or otherwise form an assembly; the thickness of plaster or brick or other material in the assembly will be included in determining the equivalent thickness. Submit calculation results.

2.5 PRECAST CONCRETE ITEMS

Trim, lintels, copings, splash blocks and door sills shall be factory-made units from a plant regularly engaged in producing precast concrete units. Unless otherwise indicated, concrete shall be 20 MPa (3000 psi) minimum conforming to Section 03 30 00 CAST-IN-PLACE CONCRETE using 13 mm (1/2 inch) to No. 4 nominal-size coarse aggregate, and minimum reinforcement shall be the reinforcement required for handling of the units. Clearance of 19 mm (3/4 inch) shall be maintained between reinforcement and faces of units. Unless precast-concrete items have been subjected during manufacture to saturated-steam pressure of at least 827 kPa (120 psi) for at least 5 hours, the items, after casting, shall be either damp-cured for 24 hours or steam-cured and shall then be aged under cover for 28 days or longer. Cast-concrete members weighing over 35 kg (80 pounds) shall have built-in loops of galvanized wire or other approved provisions for lifting and anchoring. Units shall have beds and joints at right angles to the face, with sharp true arises and shall be cast with drip grooves on the underside where units overhang walls. Exposed-to-view surfaces shall be free of surface voids, spalls, cracks, and chipped or broken edges. Precast units exposed-to-view shall be of uniform appearance and color. Unless otherwise specified, units shall have a smooth dense finish. Prior to use, each item shall be wetted and inspected for crazing. Items showing evidence of dusting, spalling, crazing, or having surfaces treated with a protective coating will be rejected.

2.5.1 Lintels

Precast lintels, unless otherwise shown, shall be of a thickness equal to the wall and reinforced with two No. 4 bars for the full length. Top of lintels shall be labeled "TOP" or otherwise identified and each lintel shall be clearly marked to show location in the structure. In reinforced masonry, lintels shall conform to ACI 318M (ACI 318) for flexural and shear strength and shall have at least 200 mm (8 inches) bearing at each end. Concrete shall have a minimum 28 day compressive strength of 20.7 MPa (3000 psi) using 13 mm (1/2 inch) to No. 4 nominal-size coarse aggregate. Reinforcement shall conform to ASTM A615/A615M Grade 400 MPa (60,000 psi). Limit lintel deflection due to dead plus live load to L/600 or 7 mm (0.3 inches). Provide top and bottom bars for lintels over 900 mm (36 inches) in length.

2.5.2 Sills and Copings

Sills and copings shall be cast with washes. Sills for windows having mullions shall be cast in sections with head joints at mullions and a 6 mm (1/4 inch) allowance for mortar joints. The ends of sills, except a 19 mm (3/4 inch) wide margin at exposed surfaces, shall be roughened for bond. Treads of door sills shall have rounded nosings. Reinforce sills with not less than two No. 15 (No. 4) bars.

2.5.3 Splash Blocks

Splash blocks shall be as detailed. Reinforcement shall be the manufacturer's standard.

2.5.4 Flue Linings and Thimbles

ASTM C315, free from fractures. Sizes and shapes shall be as indicated.

2.6 STONE ITEMS

Stone for trim, sills, lintels, and copings shall be limestone, sandstone, or granite, and shall be cut to the design shown. Sandstone shall be standard grade, buff, gray, or buff brown, with a smooth finish free from clay pits and tool marks. Granite shall be a good commercial grade building granite of medium or moderately coarse grain, and a light or medium gray or light pink color, with a smooth machine finish on washes, 4-cut finish on treads, and 6-cut or equivalent machine finish on other exposed surfaces. Limestone shall be standard buff limestone with a smooth machine finish free from tool marks. Lintels, except when supported by a steel member, shall be 100 mm (4 inches) or more thick from face to back edge and of the depth required to support the masonry over the opening. Stone shall have beds and joints at right angles to the face, with sharp, true arises. Copings and sills shall be provided with washes, and where overhanging the walls, shall have drips cut on the underside.

2.7 MORTAR FOR STRUCTURAL MASONRY

ASTM C270, Type M, or KS L 5219, Type M, or KS L 5220. Strength (f'm) as indicated. Test in accordance with ASTM C780. Use Masonry cement. Do not use admixtures containing chlorides. When structural reinforcement is incorporated, maximum air-content shall be 12 percent in cement-lime mortar and 18 percent in masonry cement mortar. Use up to 40 percent Class F fly ash with type IP cement in cement-lime mortar. Fly ash shall comply with ASTM C593.

2.8 MASONRY MORTAR

Type M mortar shall conform to ASTM C270 and shall be used for foundation walls , basement walls, and piers. Mortar Type S and N shall conform to the proportion specification of ASTM C270 except Type S cement-lime mortar proportions shall be 1 part cement, 1/2 part lime and 4-1/2 parts aggregate; Type N cement-lime mortar proportions shall be 1 part cement, 1 part lime and 6 parts aggregate. Type N or S mortar shall be used for non-load-bearing, non-shear-wall interior masonry; approved commercial fire clay mortar or refractory cement (calcium-aluminate) mortar for fire brick and flue liners; and Type S for remaining masonry work; except where higher compressive strength is indicated on structural drawings. When masonry cement ASTM C91/C91M is used the maximum air content shall be limited to 12 percent and performance equal to cement-lime mortar shall be verified. Verification of masonry cement performance shall be based on ASTM C780 and ASTM C1072. Pointing mortar in showers and kitchens shall contain ammonium stearate, or aluminum tri-stearate, or calcium stearate in an amount equal to 3 percent by weight of cement used. Cement shall have a low alkali content and be of one brand. Aggregates shall be from one source. Appropriate type of masonry cement conforming to KS L 5219 and masonry mortar conforming to KS L 5220 may be used.

2.8.1 Admixtures for Masonry Mortar

In cold weather, a non-chloride based accelerating admixture may be used subject to approval. Accelerating admixture shall be non-corrosive, shall contain less than 0.2 percent chlorides, and shall conform to ASTM C494/C494M, Type C, or KS F 2560.

2.8.2 Colored Mortar

Mortar coloring shall be added to the mortar used for exposed masonry surfaces to produce a uniform color. Quantity of pigment to cementitious content of the masonry cement shall not exceed 5 by weight; carbon black shall not exceed 1percent by weight. Quantity of pigment to cementitious content of cement-lime mix shall not exceed 10percent by weight, carbon black no more than 2percent by weight. Mortar coloring shall be chemically inert, of finely ground limeproof pigment, and furnished in accurately pre-measured and packaged units that can be added to a measured amount of cement.

2.8.3 Hydrated Lime and Alternates

Hydrated lime shall conform to ASTM C207, Type S or SA.

2.8.4 Cement

Portland cement shall conform to ASTM C150/C150M or KS L 5201, Type I, II, or III. Masonry cement shall conform to ASTM C91/C91M, Type N, S, or M. Containers shall bear complete instructions for proportioning and mixing to obtain the required types of mortar. Incorporate to the maximum extent, without conflicting with other requirements of this section, up to 40 percent fly ash, up to 70 percent slag, up to 10 percent cenospheres, and up to 10 percent silica fume. When masonry cement is used, submit the manufacturer's printed instructions on proportions of water and aggregates and on mixing to obtain the type of mortar required. Additives shall conform to requirements in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.8.5 Pre-Mixed Mortar

Pre-mixed mortar shall conform to ASTM C1142Type as indicated. Submit pre-mixed mortar composition.

2.8.6 Sand and Water

Sand shall conform to ASTM C144. Water shall be clean, potable, and free from substances which could adversely affect the mortar.

2.9 WATER-REPELLANT ADMIXTURE

Polymeric type formulated to reduce porosity and water penetration and water absorption of the mortar and masonry units.

2.10 GROUT AND READY-MIXED GROUT

Grout shall conform to ASTM C476, fine or coarse, or KS F 4009.Cement used in grout shall have a low alkali content. Grout slump shall be between 200 and 250 mm (8 and 10 inches). Minimum grout strength shall be 14 MPa (2000 psi) in 28 days, as tested by ASTM C1019. Use grout subject to the limitations of Table III. Do not change proportions and do not use materials with different physical or chemical characteristics in grout for the work unless additional evidence is furnished that the grout meets the specified requirements. Ready-Mixed grout shall conform to ASTM C94/C94M.

2.10.1 Admixtures for Grout

In cold weather, a non-chloride based accelerating admixture may be used subject to approval; accelerating admixture shall be non-corrosive, shall contain less than 0.2 percent chlorides, and shall conform to ASTM C494/C494M, Type C, or KS F 2560. In general, air-entrainment, anti-freeze or chloride admixtures shall not be used except as approved by the Contracting Officer. Submit required certifications.

2.10.2 Grout Barriers

Grout barriers for vertical cores shall consist of fine mesh wire, fiberglass, or expanded metal.

2.11 ANCHORS, TIES, AND BAR POSITIONERS

Anchors and ties shall be fabricated without drips or crimps and shall be zinc-coated in accordance with ASTM A153/A153M, Class B-2, or KS D 8308. Steel wire used for anchors and ties shall be fabricated from steel wire conforming to ASTM A82/A82M. Wire ties or anchors in exterior walls shall conform to ASTM A641/A641M. Joint reinforcement in interior walls, and in exterior or interior walls exposed to moist environment shall conform to ASTM A641/A641M; coordinate with paragraph JOINT REINFORCEMENT below. Anchors and ties shall be sized to provide a minimum of 16 mm (5/8 inch) mortar cover from either face. Submit two anchors, ties and bar positioners of each type used, as samples.

2.11.1 Wire Mesh Ties

Wire mesh for tying 100 mm (4 inch) thick concrete masonry unit partitions to other intersecting masonry partitions shall be 13 mm (1/2 inch) mesh of minimum 16 gauge (16 gauge) steel wire. Minimum lengths shall be not less than 300 mm (12 inches).

2.11.2 Wall Ties

Provide wall ties rectangular-shaped or Z-shaped fabricated of 5 mm (3/16 inch) diameter zinc-coated steel wire. Rectangular wall ties shall be no less than 100 mm (4 inches) wide. Wall ties may also be of a continuous type conforming to paragraph JOINT REINFORCEMENT. Adjustable type wall ties, if approved for use, shall consist of two essentially U-shaped elements fabricated of 5 mm (3/16 inch) diameter zinc-coated steel wire. Adjustable ties shall be of the double pintle to eye type and shall allow a maximum of 13 mm (1/2 inch) eccentricity between each element of the tie. Play between pintle and eye opening shall be not more than 2 mm (1/16 inch). The pintle and eye elements shall be formed so that both can be in the same plane.

2.11.3 Dovetail Anchors

Provide dovetail anchors of the flexible wire type, 5 mm (3/16 inch) diameter zinc-coated steel wire, triangular shaped, and attached to a 12 gauge (12 gauge) or heavier steel dovetail section. Use these anchors for anchorage of veneer wythes or composite-wall facings extending over the face of concrete columns, beams, or walls. Fill cells within vertical planes of these anchors solid with grout for full height of walls or partitions, or solid units may be used. Dovetail slots are specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.11.4 Adjustable Anchors

Adjustable anchors shall be 5 mm (3/16 inch) diameter steel wire, triangular-shaped. Anchors attached to steel shall be 8 mm (5/16 inch) diameter steel bars placed to provide 2 mm (1/16 inch) play between flexible anchors and structural steel members. Spacers shall be welded to rods and columns. Equivalent welded-on steel anchor rods or shapes standard with the flexible-anchor manufacturer may be furnished when approved. Welds shall be cleaned and given one coat of zinc-rich touch up paint.

2.11.5 Bar Positioners

Bar positioners, used to prevent displacement of reinforcing bars during the course of construction, shall be factory fabricated from 9 gauge steel wire or equivalent, and coated with a hot-dip galvanized finish. Not more than one wire shall cross the cell.

2.12 JOINT REINFORCEMENT

Joint reinforcement shall be factory fabricated from steel wire conforming to ASTM A82/A82M or KS D 3552, welded construction. Tack welding will not be acceptable in reinforcement used for wall ties. Wire shall have zinc coating conforming to ASTM A153/A153M, Class B-2. All wires shall be a minimum of 9 gauge. Reinforcement shall be ladder type design, having one longitudinal wire in the mortar bed of each face shell for hollow units and one wire for solid units. Joint reinforcement shall be placed a minimum of 16 mm (5/8 inch) cover from either face. The distance between crosswires shall not exceed 400 mm (16 inches). Joint reinforcement for straight runs shall be furnished in flat sections not less than 3 m (10 feet) long. Joint reinforcement shall be provided with factory formed corners and intersections. If approved for use, joint reinforcement may be furnished with adjustable wall tie features. Submit one piece of each type used, including corner and wall intersection pieces, showing at least two cross wires.

2.13 REINFORCING STEEL BARS AND RODS

Reinforcing steel bars and rods shall conform to ASTM A615/A615M, Grade 60.

2.14 CONTROL JOINT KEYS

Control joint keys shall be a factory fabricated solid section of natural or synthetic rubber (or combination thereof) conforming to ASTM D2000or polyvinyl chloride conforming to ASTM D2287 or KS M 3501. The material shall be resistant to oils and solvents. The control joint key shall be provided with a solid shear section not less than 16 mm (5/8 inch) thick and 10 mm (3/8 inch) thick flanges, with a tolerance of plus or minus 2 mm (1/16 inch). The control joint key shall fit neatly, but without forcing, in masonry unit jamb sash grooves. The control joint key shall be flexible at a temperature of minus 34 degrees C (minus 30 degrees F) after five hours exposure, and shall have a durometer hardness of not less than 70 when tested in accordance with ASTM D2240.

2.15 RIGID BOARD-TYPE INSULATION

Provide rigid board-type insulation as specified in Section 07 21 13 BOARD AND BLOCK INSULATION. 2.16 EXPANSION-JOINT MATERIALS

Backer rod and sealant shall be adequate to accommodate joint compression equal to 50 percent of the width of the joint. The backer rod shall be compressible rod stock of polyethylene foam, polyurethane foam, butyl rubber foam, or other flexible, nonabsorptive material as recommended by the sealant manufacturer. Sealant shall conform to Section 07 92 00 JOINT SEALANTS. Submit one piece of each type of material used.

2.17 THROUGH WALL FLASHING

Provide Through Wall Flashing as specified in Section 07 60 00 FLASHING AND SHEET METAL. Provide one of the following types except that flashing indicated to terminate in reglets shall be metal or coated-metal flashing and except that the material shall be one which is not adversely affected by dampproofing material.

a. Coated-Copper Flashing: 0.2 kg (7 ounce), electrolytic copper sheet, uniformly coated on both sides with acidproof, alkaliproof, elastic bituminous compound. Factory apply coating to a weight of not less than 1.8 kg/square meter (6 ounces/square foot) (approximately 0.9 kg/square meter (3 ounces/square foot) on each side).

b. Copper or Stainless Steel Flashing: Copper, ASTM B370, minimum 450 kg (16 ounce) weight; stainless steel, ASTM A167, Type 301, 302, 304, or 316, 0.4 mm (0.015 inch) thick, No. 2D finish. Provide with factory-fabricated deformations that mechanically bond flashing against horizontal movement in all directions. Deformations shall consist of dimples, diagonal corrugations, or a combination of dimples and transverse corrugations.

c. Reinforced Membrane Flashing: Polyester film core with a reinforcing fiberglass scrim bonded to one side. The membrane shall be impervious to moisture, flexible, and not affected by caustic alkalis. The material, after being exposed for not less than 1/2 hour to a temperature of 0 degrees C (32 degrees F), shall show no cracking when, at that temperature, it is bent 180 degrees over a 2 mm (1/16 inch) diameter mandrel and then bent at the same point over the same size mandrel in the opposite direction 360 degrees.

2.18 WEEP HOLE VENTILATORS

Weep hole ventilators shall be prefabricated aluminum, plastic or wood blocking sized to form the proper size opening in head joints. Provide aluminum and plastic inserts with grill or screen-type openings designed to allow the passage of moisture from cavities and to prevent the entrance or insects. Ventilators shall be sized to match modular construction with a standard 10 mm (3/8 inch) mortar joint.

2.19 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Prior to start of work, masonry inspector shall verify the applicable conditions as set forth in ACI 530/530.1, inspection. The Contracting Officer will serve as inspector or will select a masonry inspector.

3.1.1 Protection

Ice or snow formed on the masonry bed shall be thawed by the application of heat. Heat shall be applied carefully until the top surface of the masonry is dry to the touch. Sections of masonry deemed frozen and damaged shall be removed before continuing construction of those sections.

a. Air Temperature 4 to 0 degrees C (40 to 32 Degrees F). Sand or mixing water shall be heated to produce mortar temperatures between 4 and 49 degrees C (40 and 120 degrees F)

b. Air Temperature 0 to minus 4 degrees C (32 to 25 Degrees F). Sand and mixing water shall be heated to produce mortar temperatures between 4 and 49 degrees C (40 and 120 degrees F). Temperature of mortar on boards shall be maintained above freezing.

c. Air Temperature minus 4 to minus 7 degrees C (25 to 20 Degrees F). Sand and mixing water shall be heated to provide mortar temperatures between 4 and 49 degrees C (40 and 120 degrees F). Temperature of mortar on boards shall be maintained above freezing. Sources of heat shall be used on both sides of walls under construction. Windbreaks shall be employed when wind is in excess of 24 km/hour (15 mph).

d. Air Temperature minus 7 degrees C (20 Degrees F) and below. Sand and mixing water shall be heated to provide mortar temperatures between 4 and 49 degrees C (40 and 120 degrees F). Enclosure and auxiliary heat shall be provided to maintain air temperature above 0 degrees C (32 degrees F). Temperature of units when laid shall not be less than minus 7 degrees C (20 degrees F).

3.1.2 Completed Masonry and Masonry Not Being Worked On

a. Mean daily air temperature 4 to 0 degrees C (40 to 32 degrees F). Masonry shall be protected from rain or snow for 24 hours by covering with weather-resistive membrane.

b. Mean daily air temperature 0 to minus 4 degrees C (32 to 25 degrees F). Masonry shall be completely covered with weather-resistant membrane for 24 hours.

c. Mean Daily Air Temperature minus 4 to minus 7 degrees C (25 to 20 degrees F). Masonry shall be completely covered with insulating blankets or equally protected for 24 hours.

d. Mean Daily Temperature minus 7 degrees C (20 degrees F) and Below. Masonry temperature shall be maintained above 0 degrees C (32 degrees F) for 24 hours by enclosure and supplementary heat, by electric heating blankets, infrared heat lamps, or other approved methods.

3.1.3 Stains

Protect exposed surfaces from mortar and other stains. When mortar joints are tooled, remove mortar from exposed surfaces with fiber brushes and wooden paddles. Protect base of walls from splash stains by covering adjacent ground with sand, sawdust, or polyethylene.

3.1.4 Loads

Do not apply uniform loads for at least 12 hours or concentrated loads for at least 72 hours after masonry is constructed. Provide temporary bracing as required.

3.1.5 Surfaces

Clean surfaces on which masonry is to be placed of laitance, dust, dirt, oil, organic matter, or other foreign materials and slightly roughen to provide a surface texture with a depth of at least 3 mm (1/8 inch). Sandblast, if necessary, to remove laitance from pores and to expose the aggregate.

3.2 LAYING MASONRY UNITS

a. Coordinate masonry work with the work of other trades to accommodate built-in items and to avoid cutting and patching. Masonry units shall be laid in running or stacked bond pattern. Facing courses shall be level with back-up courses, unless the use of adjustable ties has been approved in which case the tolerances shall be plus or minus 13 mm (1/2 inch). Each unit shall be adjusted to its final position while mortar is still soft and plastic.

b. Units that have been disturbed after the mortar has stiffened shall be removed, cleaned, and relaid with fresh mortar. Air spaces, cavities, chases, expansion joints, and spaces to be grouted shall be kept free from mortar and other debris. Units used in exposed masonry surfaces shall be selected from those having the least amount of chipped edges or other imperfections detracting from the appearance of the finished work. Vertical joints shall be kept plumb.

c. Units being laid and surfaces to receive units shall be free of water film and frost. Solid units shall be laid in a nonfurrowed full bed of mortar. Mortar for veneer wythes shall be beveled and sloped toward the center of the wythe from the cavity side. Units shall be shoved into place so that the vertical joints are tight. Vertical joints of brick and the vertical face shells of concrete masonry units, except where indicated at control, expansion, and isolation joints, shall be completely filled with mortar. Mortar will be permitted to protrude up to 13 mm (1/2 inch) into the space or cells to be grouted. Means shall be provided to prevent mortar from dropping into the space below.

d. In double wythe construction, the inner wythe may be brought up not more than 400 mm (16 inches) ahead of the outer wythe. Collar joints shall be filled with mortar or grout during the laying of the facing wythe, and filling shall not lag the laying of the facing wythe by more than 200 mm (8 inches).

3.2.1 Forms and Shores

Provide bracing and scaffolding as required. Design bracing to resist wind pressure as required by local codes. Forms and shores shall be sufficiently rigid to prevent deflections which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout. Supporting forms and shores shall not be removed in less than 10 days.

3.2.2 Reinforced Concrete Masonry Units Walls

Where vertical reinforcement occurs, fill cores solid with grout. Lay units in such a manner as to preserve the unobstructed vertical continuity of cores to be filled. Embed the adjacent webs in mortar to prevent leakage of grout. Remove mortar fins protruding from joints before placing grout. Minimum clear dimensions of vertical cores shall be 50 by 75 mm (2 by 3 inches). Position reinforcing accurately as indicated before placing grout. As masonry work progresses, secure vertical reinforcing in place at vertical intervals not to exceed 160 bar diameters. Use puddling rod or vibrator to consolidate the grout. Minimum clear distance between masonry and vertical reinforcement shall be not less than 13 mm (1/2 inch). Unless indicated or specified otherwise, form splices by lapping bars not less than 40 bar diameters and wire tying them together.

3.2.3 Concrete Masonry Units

Units in piers, pilasters, columns, starting courses on footings, solid foundation walls, lintels, and beams, and where cells are to be filled with grout shall be full bedded in mortar under both face shells and webs. Other units shall be full bedded under both face shells. Head joints shall be filled solidly with mortar for a distance in from the face of the unit not less than the thickness of the face shell. Foundation walls below grade shall be grouted solid. Jamb units shall be of the shapes and sizes to conform with wall units. Solid units may be incorporated in the masonry work where necessary to fill out at corners, gable slopes, and elsewhere as approved. Double walls shall be stiffened at wall-mounted plumbing fixtures by use of strap anchors, two above each fixture and two below each fixture, located to avoid pipe runs, and extending from center to center of the double wall. Walls and partitions shall be adequately reinforced for support of wall-hung plumbing fixtures when chair carriers are not specified.

3.2.4 Clay or Shale Brick Units

Lay brick facing with the better face exposed. Lay brick in running bond with each course bonded at corners, unless otherwise indicated. Lay molded brick with the frog side down. Brick that is cored, recessed, or has other deformations may be used in sills, treads, soldier courses, except where deformations will be exposed to view. Lay fire brick by dipping each brick in a soft mixture of fire clay and water and then rubbing the brick into place with joints as thin as practicable or provide refractory mortar with joints not more than 10 mm (3/8 inch) thick.

3.2.4.1 Wetting of Units

Wetting of clay, shale brick, or hollow brick units having an initial rate of absorption of more than 0.155 gm per minute per square cm (1 gram per minute per square inch) of bed surface shall be in conformance with ASTM C67. The method of wetting shall ensure that each unit is nearly saturated but surface dry when laid. Test clay or shale brick daily on the job, prior to laying, as follows: Using a wax pencil, draw a circle the size of a quarter on five randomly selected bricks. Apply 20 drops of water with a medicine dropper to the surface within the circle on each brick. If the average time that the water is completely absorbed in the five bricks is less than 1-1/2 minutes, wet bricks represented by the five bricks tested.

3.2.4.2 Solid Units

Completely fill bed, head, and collar joints with mortar.

3.2.4.3 Hollow Units

Lay hollow units as specified for concrete masonry units.

3.2.4.4 Brick-Faced Walls

For brick-faced walls bond the two wythes in every sixth brick course with continuous horizontal joint reinforcement, unless otherwise indicated on contract drawings Provide additional bonding ties spaced not more than one meter (3 feet) apart around the perimeter of and within 300 mm (12 inches) of all openings.

a. Collar Joints: Fill collar joints solid with mortar as each course of brick is laid. Do not disturb units in place.

b. Brick Sills: Lay brick on edge, slope, and project not less than 13 mm (1/2 inch) beyond the face of the wall to form a wash and drip. Fill all joints solidly with mortar and tool.

3.2.4.5 Cavity Walls

Provide a continuous cavity as indicated. Securely tie the two wythes together with horizontal joint reinforcement. Bevel mortar beds away from cavity to prevent projection into cavity when bricks are shoved in place. Keep cavities clear and clean of mortar droppings. At the bottom of cavity walls, in the course immediately above the through-wall flashing, temporarily omit one brick every 1200 mm (4 feet). With a hose and clean water, wash all mortar droppings and debris out of the cavity through the temporary openings at least twice each day masonry is laid, and more often when required to keep the cavities clean. Fill in the openings with bricks and mortar after the wall is complete and the cavity has been inspected and found clean. Provide weep holes of open head joints spaced 600 mm (24 inches) o.c.

3.2.4.6 Reinforced Brick Walls

Bevel mortar beds away from grout space to prevent projection into grout space when bricks are shoved in place. Deeply furrowed bed joints will not be permitted. Lay exterior wythe of brick to the height of each grout pour in advance of interior wythe. Clean grout space and set reinforcing before laying interior wythe. Provide metal ties to prevent spreading of the wythes and to maintain vertical alignment of walls. Position reinforcing as indicated. Wire vertical reinforcing securely in position as the brickwork progresses. Use puddling rod or vibrator to consolidate the grout. The minimum clear distance between parallel bars shall be the nominal diameter of the bars; the minimum clear distance between masonry and reinforcing shall be 6 mm (1/4 inch). Unless indicated or specified otherwise, form splices by lapping bars not less than 40 bar diameters and wire tying them together. Stagger splices in adjacent horizontal bars.

3.2.4.7 Chimneys

Construct chimneys of brick with clay flue linings of the sizes indicated. Extend flue linings from 300 mm (12 inches) below the smoke inlet to 100 mm (4 inches) above the chimney cap. Place thimbles as indicated, flush with inside of or up to 25 mm (one inch) into the flue lining. Set linings in fire clay mortar or refractory mortar and fill and smooth the joints on the inside. Set each section of flue lining before surrounding brickwork reaches top of flue lining section below. Build brickwork around lining, and leave a 25 mm (one inch) airspace between lining and brickwork. Seal top of airspace before installing chimney cap. Do not cut linings after they are installed in chimney. Unless indicated otherwise, provide a chimney cap of air-entrained concrete. Slope cap to a minimum edge thickness of 50 mm (2 inches) and reinforce with two rings of No. 3 gage galvanized steel wire.

3.2.4.8 Brick Veneer

Provide a continuous cavity as indicated. Install brick veneer after sheathing, masonry anchors, and flashing have been installed to the cold-formed steel framing system. Care shall be provided to avoid damaging the moisture barrier. Damaged moisture barrier and flashing shall be repaired or replaced before brick veneer is installed. Means shall be provided to keep cavities clean and clear of mortar droppings.

3.2.5 Tolerances

Lay masonry plumb, true to line, with courses level. Keep bond pattern plumb throughout. Square corners unless noted otherwise. Except for walls constructed of prefaced concrete masonry units, lay masonry within the following tolerances (plus or minus unless otherwise noted):

TABLE II TOLERANCES	
Variation from the plumb in the lines and surfaces of columns, walls and arises	
In adjacent masonry units	3 mm (1/8 inch)
In 3 m (10 feet)	6 mm (1/4 inch)
In 6 m (20 feet)	10 mm (3/8 inch)
In 12 m (40 feet) or more	13 mm (1/2 inch)
Variations from the plumb for external corners, expansion joints, and other conspicuous lines	
In 6 m (20 feet)	6 mm (1/4 inch)
In 12 m (40 feet) or more	13 mm (1/2 inch)
Variations from the level for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines	
In 6 m (20 feet)	6 mm (1/4 inch)
In 12 m (40 feet) or more	13 mm (1/2 inch)
Variation from level for bed joints and top surfaces of bearing walls	
In 3 m (10 feet)	6 mm (1/4 inch)
In 12 m (40 feet) or more	13 mm (1/2 inch)
Variations from horizontal lines	
In 3 m (10 feet)	6 mm (1/4 inch)
In 6 m (20 feet)	10 mm (3/8 inch)
In 12 m (40 feet) or more	13 mm (1/2 inch)
Variations in cross sectional dimensions of columns and in thickness of walls	
Minus	6 mm (1/4 inch)
Plus	13 mm (1/2 inch)

3.2.6 Cutting and Fitting

Full units of the proper size shall be used wherever possible, in lieu of cut units. Cutting and fitting, including that required to accommodate the work of others, shall be done by masonry mechanics using power masonry saws. Concrete masonry units may be wet or dry cut. Wet cut units, before being placed in the work, shall be dried to the same surface-dry appearance as uncut units being laid in the wall. Cut edges shall be clean, true and sharp. Openings in the masonry shall be made carefully so that wall plates, cover plates or escutcheons required by the installation will completely conceal the openings and will have bottoms parallel with the masonry bed joints. Reinforced masonry lintels shall be provided above openings over 300 mm (12 inches) wide for pipes, ducts, cable trays, and other wall penetrations, unless steel sleeves are used.

3.2.7 Jointing

Joints shall be tooled when the mortar is thumbprint hard. Horizontal joints shall be tooled last. Joints shall be brushed to remove all loose and excess mortar. Mortar joints shall be finished as follows:

3.2.7.1 Flush Joints

Joints in concealed masonry surfaces and joints at electrical outlet boxes in wet areas shall be flush cut. Flush cut joints shall be made by cutting off the mortar flush with the face of the wall. Joints in unparged masonry walls below grade shall be pointed tight. Flush joints for architectural units, such as fluted units, shall completely fill both the head and bed joints.

3.2.7.2 Tooled Joints

Joints in exposed exterior and interior masonry surfaces shall be tooled slightly concave. Joints shall be tooled with a jointer slightly larger than the joint width so that complete contact is made along the edges of the unit. Tooling shall be performed so that the mortar is compressed and the joint surface is sealed. Jointer of sufficient length shall be used to obtain a straight and true mortar joint.

3.2.7.3 Door and Window Frame Joints

On the exposed interior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of 10 mm (3/8 inch). On the exterior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of 10 mm (3/8 inch).

3.2.8 Joint Widths

Joint widths shall be as follows:

3.2.8.1 Concrete Masonry Units

Concrete masonry units shall have 10 mm (3/8 inch) joints, except for prefaced concrete masonry units.

3.2.8.2 Prefaced Concrete Masonry Units

Prefaced concrete masonry units shall have a joint width of 10 mm (3/8 inch) wide on unfaced side and not less than 5 mm (3/16 inch) nor more than 6 mm (1/4 inch) wide on prefaced side.

3.2.8.3 Brick

Brick joint widths shall be the difference between the actual and nominal dimensions of the brick in either height or length. Brick expansion joint widths shall be as shown.

3.2.9 Embedded Items

Fill spaces around built-in items with mortar. Point openings around flush-mount electrical outlet boxes in wet locations with mortar. Embed anchors, ties, wall plugs, accessories, flashing, pipe sleeves and other items required to be built-in as the masonry work progresses. Fully embed anchors, ties and joint reinforcement in the mortar. Fill cells receiving anchor bolts and cells of the first course below bearing plates with grout.

3.2.10 Unfinished Work

Step back unfinished work for joining with new work. Toothing may be resorted to only when specifically approved. Remove loose mortar and thoroughly clean the exposed joints before laying new work.

3.2.11 Masonry Wall Intersections

Masonry bond each course at corners and elsewhere as shown. Masonry walls shall be anchored or tied together at corners and intersections with bond beam reinforcement and prefabricated corner or tee pieces of joint reinforcement as shown.

3.2.12 Partitions

Partitions shall be continuous from floor to underside of floor or roof deck where shown. Openings in firewalls around joists or other structural members shall be filled as indicated or approved. Where suspended ceilings on both sides of partitions are indicated, the partitions other than those shown to be continuous may be stopped approximately 100 mm (4 inches) above the ceiling level. An isolation joint shall be placed in the intersection between partitions and structural or exterior walls as shown. Interior partitions having 100 mm (4 inch) nominal thick units shall be tied to intersecting partitions of 100 mm (4 inch) units, 125 mm (5 inches) into partitions of 150 mm (6 inch) units, and 175 (7 inches) into partitions of 200 mm (8 inch) or thicker units. Cells within vertical plane of ties shall be filled solid with grout for full height of partition or solid masonry units may be used. Interior partitions having masonry walls over 100 mm (4 inches) thick shall be tied together with joint reinforcement. Partitions containing joint reinforcement shall be provided with prefabricated pieces at corners and intersections or partitions.

3.3 ANCHORED VENEER CONSTRUCTION

Completely separate the inner and outer wythes by a continuous airspace as indicated. Lay up both the inner and the outer wythes together except when adjustable joint reinforcement assemblies are approved for use. When both wythes are not brought up together, through-wall flashings shall be protected from damage until they are fully enclosed in the wall. The airspace between the wythes shall be kept clear and free of mortar droppings by temporary wood strips laid on the wall ties and carefully lifted out before placing the next row of ties. A coarse gravel or drainage material shall be placed behind the weep holes in the cavity to a minimum depth of 100 mm (4 inches) of coarse aggregate or 250 mm (10 inches) of drainage material to keep mortar droppings from plugging the weep holes.

3.4 WEEP HOLES

Wherever through-wall flashing occurs, provide weep holes to drain flashing to exterior at acceptable locations as indicated on drawings. Weep holes shall be clear round holes not less than 6 mm (1/4 inch) in diameter at 600 mm (24 inches) o.c. Weep holes shall be provided not more than 600 mm (24 inches) on centers in mortar joints of the exterior wythe above wall flashing, over foundations, bond beams, and any other horizontal interruptions of the cavity. Weep holes shall be perfectly horizontal or slightly canted downward to encourage water drainage outward and not inward. Weep holes shall be constructed using weep hole ventilators. Other approved methods may be used for providing weep holes. Weep holes shall be kept free of mortar and other obstructions.

3.5 COMPOSITE WALLS

Tie masonry wythes together with joint reinforcement or with unit wall ties. Anchor facing to concrete backing with wire dovetail anchors set in slots built in the face of the concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Anchor or tie the facing wythe to the backup at a maximum spacing of 400 mm (16 inches) on center vertically and 600 mm (24 inches) on center horizontally. Unit ties shall be spaced not over 600 mm (24 inches) on centers horizontally, in courses not over 400 mm (16 inches) apart vertically, staggered in alternate courses. Ties shall be laid not closer than 16 mm (5/8 inch) to either masonry face. Ties shall not extend through control joints. Collar joints between masonry facing and masonry backup shall be filled solidly with grout.

3.6 MORTAR MIX

Mix mortar in a mechanically operated mortar mixer for at least 3 minutes, but not more than 5 minutes. Measure ingredients for mortar by volume. Ingredients not in containers, such as sand, shall be accurately measured by the use of measuring boxes. Mix water with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the vertical surfaces of masonry units. Retemper mortar that has stiffened because of loss of water through evaporation by adding water to restore the proper consistency and workability. Discard mortar that has reached its initial set or that has not been used within 2.5 hours after mixing.

3.7 REINFORCING STEEL

Clean reinforcement of loose, flaky rust, scale, grease, mortar, grout, or other coating which might destroy or reduce its bond prior to placing grout. Bars with kinks or bends not shown on the drawings shall not be used. Reinforcement shall be placed prior to grouting. Unless otherwise indicated, vertical wall reinforcement shall extend to within 50 mm (2 inches) of tops of walls.

3.7.1 Positioning Bars

Vertical bars shall be accurately placed within the cells at the positions indicated on the drawings. A minimum clearance of 13 mm (1/2 inch) shall be maintained between the bars and masonry units. Minimum clearance between parallel bars shall be one diameter of the reinforcement. Vertical reinforcing may be held in place using bar positioners located near the ends of each bar and at intermediate intervals of not more than 192 diameters of the reinforcement. Column and pilaster ties shall be wired in position around the vertical steel. Ties shall be in contact with the vertical reinforcement and shall not be placed in horizontal bed joints.

3.7.2 Splices

Bars shall be lapped a minimum of 48 diameters of the reinforcement. Welded or mechanical connections shall develop at least 125 percent of the specified yield strength of the reinforcement.

3.8 JOINT REINFORCEMENT INSTALLATION

Joint reinforcement shall be installed at 400 mm (16 inches) on center or as indicated. Reinforcement shall be lapped not less than 150 mm (6 inches). Prefabricated sections shall be installed at corners and wall intersections. The longitudinal wires of joint reinforcement shall be placed to provide not less than 16 mm (5/8 inch) cover to either face of the unit.

3.9 PLACING GROUT

Fill cells containing reinforcing bars with grout. Hollow masonry units in walls or partitions supporting plumbing, heating, or other mechanical fixtures, voids at door and window jambs, and other indicated spaces shall be filled solid with grout. Cells under lintel bearings on each side of openings shall be filled solid with grout for full height of openings. Walls below grade, lintels, and bond beams shall be filled solid with grout. Units other than open end units may require grouting each course to preclude voids in the units. Grout not in place within 1-1/2 hours after water is first added to the batch shall be discarded. Sufficient time shall be allowed between grout lifts to preclude displacement or cracking of face shells of masonry units. If blowouts, flowouts, misalignment, or cracking of face shells should occur during construction, the wall shall be torn down and rebuilt.

3.9.1 Vertical Grout Barriers for Fully Grouted Walls

Provide grout barriers not more than 10 m (30 feet) apart, or as required, to limit the horizontal flow of grout for each pour.

3.9.2 Horizontal Grout Barriers

Embed grout barriers in mortar below cells of hollow units receiving grout.

3.9.3 Grout Holes and Cleanouts

3.9.3.1 Grout Holes

Provide grouting holes in slabs, spandrel beams, and other in-place overhead construction. Locate holes over vertical reinforcing bars or as required to facilitate grout fill in bond beams. Provide additional openings spaced not more than 400 mm (16 inches) on centers where grouting of all hollow unit masonry is indicated. Openings shall not be less than 100 mm (4 inches) in diameter or 75 by 100 mm (3 by 4 inches) in horizontal dimensions. Upon completion of grouting operations, plug and finish grouting holes to match surrounding surfaces.

3.9.3.2 Cleanouts for Hollow Unit Masonry Construction

Provide cleanout holes at the bottom of every pour in cores containing vertical reinforcement when the height of the grout pour exceeds 1.5 m (5 feet). Where all cells are to be grouted, construct cleanout courses using bond beam units in an inverted position to permit cleaning of all cells. Provide cleanout holes at a maximum spacing of 800 mm (32 inches) where all cells are to be filled with grout. Establish a new series of cleanouts if grouting operations are stopped for more than 4 hours. Cleanouts shall not be less than 75 by 100 mm (3 by 4 inch) openings cut from one face shell. Manufacturer's standard cutout units may be used at the Contractor's option. Cleanout holes shall not be closed until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, close cleanout holes in an approved manner to match surrounding masonry.

3.9.3.3 Cleanouts for Solid Unit Masonry Construction

Provide cleanouts for construction of walls consisting of a grout filled cavity between solid masonry wythes at the bottom of every pour by omitting every other masonry unit from one wythe. Establish a new series of cleanouts if grouting operations are stopped for more than 4 hours. Do not plug cleanout holes until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, close cleanout holes in an approved manner to match surrounding masonry.

3.9.4 Grouting Equipment

3.9.4.1 Grout Pumps

Pumping through aluminum tubes will not be permitted. Operate pumps to produce a continuous stream of grout without air pockets, segregation, or contamination. Upon completion of each day's pumping, remove waste materials and debris from the equipment, and dispose of outside the masonry.

3.9.4.2 Vibrators

Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the grout. Maintain at least one spare vibrator at the site at all times. Apply vibrators at uniformly spaced points not further apart than the visible effectiveness of the machine. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

3.9.5 Grout Placement

Lay masonry to the top of a pour before placing grout. Do no place grout in two-wythe solid unit masonry cavity until mortar joints have set for at least 3 days during hot weather and 5 days during cold damp weather. Grout shall not be placed in hollow unit masonry until mortar joints have set for at least 24 hours. Grout shall be placed using a hand bucket, concrete hopper, or grout pump to completely fill the grout spaces without segregation of the aggregates. Vibrators shall not be inserted into lower pours that are in a semi-solidified state. The height of grout pours and type of grout used shall be limited by the dimensions of grout spaces as indicated in Table III. Low-lift grout methods may be used on pours up to and including 1.5 m (5 feet) in height. High-lift grout methods shall be used on pours exceeding 1.5 m (5 feet) in height.

3.9.5.1 Low-Lift Method

Grout shall be placed at a rate that will not cause displacement of the masonry due to hydrostatic pressure of the grout. Mortar protruding more than 13 mm (1/2 inch) into the grout space shall be removed before beginning the grouting operation. Grout pours 300 mm (12 inches) or less in height shall be consolidated by mechanical vibration or by puddling. Grout pours over 300 mm (12 inches) in height shall be consolidated by mechanical vibration and reconsolidated by mechanical vibration after initial water loss and settlement has occurred. Vibrators shall not be inserted into lower pours that are in a semi-solidified state. Low-lift grout shall be used subject to the limitations of Table III.

3.9.5.2 High-Lift Method

Mortar droppings shall be cleaned from the bottom of the grout space and from reinforcing steel. Mortar protruding more than 6 mm (1/4 inch) into the grout space shall be removed by dislodging the projections with a rod or stick as the work progresses. Reinforcing, bolts, and embedded connections shall be rigidly held in position before grouting is started. CMU units shall not be pre-wetted. Grout, from the mixer to the point of deposit in the grout space shall be placed as rapidly as practical by pumping and placing methods which will prevent segregation of the mix and cause a minimum of grout splatter on reinforcing and masonry surfaces not being immediately encased in the grout lift. The individual lifts of grout shall be limited to 1.2 m (4 feet) in height. The first lift of grout shall be placed to a uniform height within the pour section and vibrated thoroughly to fill all voids. This first vibration shall follow immediately behind the pouring of the grout using an approved mechanical vibrator. After a waiting period sufficient to permit the grout to become plastic, but before it has taken any set, the succeeding lift shall be poured and vibrated 300 to 450 mm (12 to 18 inches) into the preceding lift. If the placing of the succeeding lift is going to be delayed beyond the period of workability of the preceding, each lift shall be reconsolidated by reworking with a second vibrator as soon as the grout has taken its settlement shrinkage. The waiting, pouring, and reconsolidation steps shall be repeated until the top of the pour is reached. The top lift shall be reconsolidated after the required waiting period. The high-lift grouting of any section of wall between vertical grout barriers shall be completed to the top of a pour in one working day unless a new series of cleanout holes is established and the resulting horizontal construction joint cleaned. High-lift grout shall be used subject to the limitations in Table III.

TABLE III
POUR HEIGHT AND TYPE OF GROUT FOR VARIOUS GROUT SPACE DIMENSIONS

			Minimum Dimensions of the Total Clear Areas Within Grout Spaces and Cells in mm (inches) (1,2)	
Maximum Grout Pour Height m feet) (4)	Grout Type	Grouting Procedure	Multiwythe Masonry (3)	Hollow-unit Masonry
0.3 (1)	Fine	Low Lift	20 (3/4)	40 x 50 (1-1/2 x 2)
1.5 (5)	Fine	Low Lift	50 (2)	50 x 75 (2 x 3)
2.4 (8)	Fine	High Lift	50 (2)	50 x 75 (2 x 3)
3.6 (12)	Fine	High Lift	65 (2-1/2)	65 x 75 (2-1/2 x 3)
7.3 (24)	Fine	High Lift	75 (3)	75 x 75 (3 x 3)
0.3 (1)	Coarse	Low Lift	40 (1-1/2)	40 x 75 (1-1/2 x 3)
1.5 (5)	Coarse	Low Lift	50 (2)	65 x 75 (2-1/2 x 3)
2.4 (8)	Coarse	High Lift	50 (2)	75 x 75 (3 x 3)
3.6 (12)	Coarse	High Lift	65 (2-1/2)	75 x 75 (3 x 3)
7.3 (24)	Coarse	High Lift	75 (3)	75 x 100 (3 x 4)

Notes:

(1) The actual grout space or cell dimension shall be larger than the sum of the following items:

(a) The required minimum dimensions of total clear areas given in the table above;

(b) The width of any mortar projections within the space;

(c) The horizontal projections of the diameters of the horizontal reinforcing bars within a cross section of the grout space or cell.

(2) The minimum dimensions of the total clear areas shall be made up of one or more open areas, with at least one area being 20 mm (3/4 inch) or greater in width.

(3) For grouting spaces between masonry wythes.

(4) Where only cells of hollow masonry units containing reinforcement are grouted, the maximum height of the pour shall not exceed the distance between horizontal bond beams.

3.10 BOND BEAMS

Bond beams shall be filled with grout and reinforced as indicated on the drawings. Grout barriers shall be installed under bond beam units to retain the grout as required. Reinforcement shall be continuous, including around corners, except through control joints or expansion joints, unless otherwise indicated on the drawings. Where splices are required for continuity, reinforcement shall be lapped 48 bar diameters. A minimum clearance of 13 mm (1/2 inch) shall be maintained between reinforcement and interior faces of units.

3.11 CONTROL JOINTS

Control joints shall be provided as indicated and shall be constructed by using mortar to fill the head joint or special control-joint units in accordance with the details shown on the drawings. Sash jamb units shall have a 19 by 19 mm (3/4 by 3/4 inch) groove near the center at end of each unit. The vertical mortar joint at control joint locations shall be continuous, including through all bond beams. This shall be accomplished by utilizing half blocks in alternating courses on each side of the joint. The control joint key shall be interrupted in courses containing continuous bond beam steel. In single wythe exterior masonry walls, the exterior control joints shall be raked to a depth of 19 mm (3/4 inch); backer rod and sealant shall be installed in accordance with Section 07 92 00 JOINT SEALANTS. Exposed interior control joints shall be raked to a depth of 6 mm (1/4 inch). Concealed control joints shall be flush cut.

3.12 JOINTS SHOWN ON THE DRAWINGS

a. Brick expansion joints

b. Concrete masonry veneer joints

c. will be located, detailed, and constructed as shown on the drawings. Keep joints free of mortar and other debris.

3.13 SHELF ANGLES

Adjust shelf angles as required to keep the masonry level and at the proper elevation. Shelf angles shall be galvanized and provided in sections not longer than 3 m (10 feet) and installed with a 6 mm ((1/4 inch) gap between sections. Shelf angles shall be mitered and welded at building corners with each angle not shorter than 1.2 m (4 feet), unless limited by wall configuration.

3.14 LINTELS

3.14.1 Masonry Lintels

Construct masonry lintels with lintel units filled solid with grout in all courses and reinforced with a minimum of two No. 4 bars in the bottom course unless otherwise indicated on the drawings. Lintel reinforcement shall extend beyond each side of masonry opening 40 bar diameters or 600 mm (24 inches), whichever is greater. Reinforcing bars shall be supported in place prior to grouting and shall be located 13 mm (1/2 inch) above the bottom inside surface of the lintel unit.

3.14.2 Precast Concrete and Steel Lintels

Construct precast concrete and steel lintels as shown on the drawings. Lintels shall be set in a full bed of mortar with faces plumb and true. Steel and precast lintels shall have a minimum bearing length of 200 mm (8 inches) unless otherwise indicated on the drawings.

3.15 SILLS AND COPINGS

Sills and copings shall be set in a full bed of mortar with faces plumb and true.

3.16 ANCHORAGE TO CONCRETE AND STRUCTURAL STEEL

3.16.1 Anchorage to Concrete

Anchorage of masonry to the face of concrete columns, beams, or walls shall be with dovetail anchors spaced not over 400 mm (16 inches) on centers vertically and 600 mm (24 inches) on center horizontally.

3.16.2 Anchorage to Structural Steel

Masonry shall be anchored to vertical structural steel framing with adjustable steel wire anchors spaced not over 400 mm (16 inches) on centers vertically, and if applicable, not over 600 mm (24 inches) on centers horizontally.

3.17 PARGING

The outside face of below-grade exterior concrete-masonry unit walls enclosing usable rooms and spaces, except crawl spaces, shall be parged with type S mortar. Parging shall not be less than 13 mm (1/2 inch) thick troweled to a smooth dense surface so as to provide a continuous unbroken shield from top of footings to a line 150 mm (6 inches) below adjacent finish grade, unless otherwise indicated. Parging shall be coved at junction of wall and footing. Parging shall be damp-cured for 48 hours or more before backfilling. Parging shall be protected from freezing temperatures until hardened.

3.18 INSULATION

Anchored veneer walls shall be insulated, where shown, by installing board-type insulation on the cavity side of the inner wythe. Board type insulation shall be applied directly to the masonry or thru-wall flashing with adhesive. Insulation shall be neatly fitted between obstructions without impaling of insulation on ties or anchors. The insulation shall be applied in parallel courses with vertical joints breaking midway over the course below and shall be applied in moderate contact with adjoining units without forcing, and shall be cut to fit neatly against adjoining surfaces.

3.19 SPLASH BLOCKS

Locate splash blocks as indicated.

3.20 POINTING AND CLEANING

After mortar joints have attained their initial set, but prior to hardening, completely remove mortar and grout daubs or splashings from masonry-unit surfaces that will be exposed or painted. Before completion of the work, defects in joints of masonry to be exposed or painted shall be raked out as necessary, filled with mortar, and tooled to match existing joints. Immediately after grout work is completed, scum and stains which have percolated through the masonry work shall be removed using a high pressure stream of water and a stiff bristled brush. Masonry surfaces shall not be cleaned, other than removing excess surface mortar, until mortar in joints has hardened. Masonry surfaces shall be left clean, free of mortar daubs, dirt, stain, and discoloration, including scum from cleaning operations, and with tight mortar joints throughout. Metal tools and metal brushes shall not be used for cleaning.

3.20.1 Dry-Brushing

a. Exposed concrete masonry unit

b. Exposed concrete brick surfaces

c. shall be dry-brushed at the end of each day's work and after any required pointing, using stiff-fiber bristled brushes.

3.20.2 Clay or Shale Brick Surfaces

Clean exposed clay or shale brick masonry surfaces as necessary to obtain surfaces free of stain, dirt, mortar and grout daubs, efflorescence, and discoloration or scum from cleaning operations. After cleaning, examine the sample panel of similar material for discoloration or stain as a result of cleaning. If the sample panel is discolored or stained, change the method of cleaning to ensure that the masonry surfaces in the structure will not be adversely affected. The exposed masonry surfaces shall be water-soaked and then cleaned with a solution proportioned 30 mL (1/2 cup) trisodium phosphate and 30 mL (1/2 cup) laundry detergent to 1 L (one gallon) of water or cleaned with a proprietary masonry cleaning agent specifically recommended for the color and texture by the clay products manufacturer. The solution shall be applied with stiff fiber brushes, followed immediately by thorough rinsing with clean water. Proprietary cleaning agents shall be used in conformance with the cleaning product manufacturer's printed recommendations. Efflorescence shall be removed in conformance with the brick manufacturer's recommendations.

3.21 BEARING PLATES

Set bearing plates for beams, joists, joist girders and similar structural members to the proper line and elevation with damp-pack bedding mortar, except where non-shrink grout is indicated. Bedding mortar and non-shrink grout shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.22 PROTECTION

Protect facing materials against staining. Cover top of walls with nonstaining waterproof covering or membrane when work is not in progress. Covering of the top of the unfinished walls shall continue until the wall is waterproofed with a complete roof or parapet system. Covering shall extend a minimum of 600 mm (2 feet) down on each side of the wall and shall be held securely in place. Before starting or resuming, top surface of masonry in place shall be cleaned of loose mortar and foreign material.

3.23 WASTE MANAGEMENT

Manage waste according to the Waste Management Plan and as follows. Minimize water used to wash mixing equipment. Use trigger operated spray nozzles for water hoses.

3.23.1 Separate and Recycle Waste

Place materials defined as hazardous or toxic waste in designated containers. Fold up metal banding, flatten, and place in designated area for recycling. Collect wood packing shims and pallets and place in designated area. Use leftover mixed mortar as retaining wall footing ballast or cavity fill at grade where lower strength mortar meets the requirements for bulk fill. Separate masonry waste and place in designated area for use as structural fill. Separate selected masonry waste and excess for landscape uses, either whole or crushed as ground cover.

3.23.2 Take-Back Program

Collect information from manufacturer for take-back program options. Set aside masonry units, full and partial, scrap or packaging to be returned to manufacturer for recycling into new product. When such a service is not available, local recyclers shall be sought after to reclaim the materials. Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

3.24 TEST REPORTS

3.24.1 Field Testing of Mortar

Take at least three specimens of mortar each day. Spread a layer of mortar 13 to 16 mm (1/2 to 5/8 inch) thick on the masonry units and allowed to stand for one minute. Prepare and test the specimens for compressive strength in accordance with ASTM C780. Submit test results.

3.24.2 Field Testing of Grout

Field sampling and testing of grout shall be in accordance with the applicable provisions of ASTM C1019. A minimum of three specimens of grout per day shall be sampled and tested. Each specimen shall have a minimum ultimate compressive strength of 13.8 MPa (2000 psi) at 28 days. Submit test results.

3.24.3 Efflorescence Test

Test brick, which will be exposed to weathering, for efflorescence. Schedule tests far enough in advance of starting masonry work to permit retesting if necessary. Sampling and testing shall conform to the applicable provisions of ASTM C67. Units meeting the definition of "effloresced" will be subject to rejection. Submit test results.

3.24.4 Prism Tests

For buildings having over 465 square meters (5,000 square feet) of new wall construction, perform at least one prism test sample for each 465 square meters (5,000 square feet) of wall but not less than three such samples shall be made for any building. Three prisms will be used in each sample. Prisms shall be tested in accordance with ACI 530/530.1. Seven-day tests may be used provided the relationship between the 7- and 28-day strengths of the masonry is established by the tests of the materials used. Compressive strength shall not be less than 13.8 MPa (2000 psi) at 28 days. If the compressive strength of any prism falls below the specified value by more than 3.5 MPa (500 psi), steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. If the likelihood of low-strength masonry is confirmed and computations indicate that the load-carrying capacity may have been significantly reduced, tests of cores drilled, or prisms sawed, from the area in question may be required. In such case, three specimens shall be taken for each prism test more than 3.5 MPa (500 psi) below the specified value. Masonry in the area in question shall be considered structurally adequate if the average compressive strength of three specimens is equal to at least 85 percent of the specified value, and if the compressive strength of no single specimen is less than 75 percent of the specified value. Additional testing of specimens extracted from locations represented by erratic core or prism strength test results will be permitted. Submit test results.

-- End of Section --

SECTION 05 05 23

WELDING, STRUCTURAL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2010) Specification for Structural Steel Buildings

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT SNT-TC-1A	(2011) Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2012) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS A3.0M/A3.0	(2010) Standard Welding Terms and Definitions
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2008; Errata 2008) Structural Welding Code - Sheet Steel
AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel
AWS D14.1/D14.1M	(2005) Specification for Welding Industrial and Mill Cranes and Other Material Handling Equipment
AWS D14.4/D14.4M	(2005) Specification for Welded Joints for Machinery and Equipment
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM E165	(2009) Standard Test Method for Liquid Penetrant Examination
ASTM E709	(2008) Standard Guide for Magnetic

Particle Examination

1.2 DEFINITIONS

Definitions of welding terms are in accordance with AWS A3.0M/A3.0. The following classifications indicate potential project classes of weld joints.

1.2.1 Class 1 Weld Joints

This covers complete penetration weld joints only. These weld joints apply where failure would cause a loss of the system and/or be hazardous to personnel. Class 1 weld joints are highly stressed (dynamic and cyclic loading) and characterized as a single point of failure with no redundancy for the redistribution of stress into another member.

1.2.2 Class 2 Weld Joints

This covers both complete and partial penetration groove weld joints and fillet weld joints. These weld joints apply where failure would reduce the overall efficiency of a system but loss of the system or a hazard to personnel would not be experienced.

1.2.3 Class 3 Weld Joints

This covers both complete and partial penetration groove weld joints and fillet weld joints. These weld joints apply where failure would not affect the efficiency of a system nor create a hazard to personnel. Class 3 weld joints are connections of secondary members not subject to dynamic action and/or low stressed miscellaneous applications.

1.2.4 Class 4 Weld Joints

This covers weld joints applicable to welding reinforcing steel to primary structural members.

1.2.5 Class 5 Weld Joints

This covers weld joints applicable to welding concrete reinforcing steel splices (prestressing steel excepted), steel connection devices, and inserts and anchors required in concrete construction.

1.2.6 Class 6 Weld Joints

This covers plug and slot weld joints as applicable to the requirements of the project's code(s).

1.3 SYSTEM DESCRIPTION

Conform the design of welded connections to AISC 360, unless otherwise indicated or specified. Material with welds will not be accepted unless the welding is specified or indicated on the drawings or otherwise approved. Perform welding as specified in this section, except where additional requirements are shown on the drawings or are specified in other sections. Do not commence welding until welding procedures, inspectors, nondestructive testing personnel, welders, welding operators, and tackers have been qualified and the submittals approved by the Contracting Officer. Perform all testing at or near the work site. Each Contractor performing welding shall maintain records of the test results obtained in welding procedure, welder, welding operator, and tacker performance qualifications.

1.3.1 Pre-erection Conference

Hold a pre-erection conference prior to the start of the field welding, to bring all affected parties together and to gain a naturally clear understanding of the project and the Welding Procedure Specifications (WPS) (which the Contractor shall develop and submit for all welding, including welding done using pre-qualified procedures). Mandatory attendance is required by all Contractor's welding production and inspection personnel and appropriate Government personnel. Include as items for discussion: responsibilities of various parties; welding procedures and processes to be followed; welding sequence (both within a joint and joint sequence within the building); inspection requirements and procedures, both visual and ultrasonic; welding schedule; fabrication of mock-up model; and other items deemed necessary by the attendees.

1.3.2 Mock-up Model

Perform first the field-welded connection designated as the mock-up model on the drawings. All welders, qualified and designated to perform field-welded groove joints, shall be present during the welding of the mock-up model connections and each one shall perform a part of the welding. Simulate with the mock-up test all physical and environmental conditions that will be encountered during the welding of all groove joints. Execute all inspection procedures required for groove welded joints, including NDE tests, on the mock-up model. All Contractor inspection and testing personnel designated to perform QC of groove welded joints shall be present during the welding of the mock-up model and each one shall perform the inspection procedures to be performed on production welding of these joints. This mock-up model connection represents the standard of performance, both for the welding and inspection procedures used and the results to be achieved in the production welding for these groove welded joints.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Welding Procedures; G

SD-06 Test Reports

Nondestructive Examination

SD-07 Certificates

Welder, Welding Operator, and Tacker Qualification
Inspector Qualification
Previous Qualifications

1.5 QUALITY ASSURANCE

Except for pre-qualified (in accordance with AWS D1.1/D1.1M) and previously qualified procedures, each Contractor performing welding shall record in detail and qualify the welding procedure specification for any welding procedure followed in the fabrication of weldments. Conform welding procedures to AWS D1.1/D1.1M and to the specifications in this section. Submit for approval copies of the welding procedure specification and the results of the procedure qualification test records for each type of welding which requires procedure qualification and the welder, welding operator, or tacker qualification test records. Approval of any procedure, however, does not relieve the Contractor of the sole responsibility for producing a finished structure meeting all the specified requirements. Submit this information on the forms in Annex M of AWS D1.1/D1.1M. Individually identify and clearly reference on the detail drawings and erection drawings all welding procedure specifications, or suitably key them to the contract drawings. In case of conflict between this specification and AWS D1.1/D1.1M, this specification governs.

1.5.1 General Requirements

To perform this work provide an organization certified in the following: American Institute of Steel Construction (AISC) Quality Certification Program Category.

a. For Structural Projects, provide documentation of the following:

   (1) Component Thickness 3 mm (1/8 inch) and greater: Qualification documents (WPS, PQR, and WPQ) in accordance with AWS D1.1/D1.1M.

   (2) Component Thickness Less than 3 mm (1/8 inch): Qualification documents (WPS, PQR, and WPQ) in accordance with AWS D1.3/D1.3M.

   (3) Reinforcing Steel: Qualification documents (WPS, PWR, and WPQ) in accordance with AWS D1.4/D1.4M.

b. For other applications, provide documentation of the following:

   (1) Submit for approval to the Contracting Officer two copies of Certified Welding Procedure Specifications (WPS), Certified Brazing Procedure Specifications (BPS) and Certified Procedure Qualification Records (PQR) within fifteen calendar days after receipt of Notice to Proceed.

   (2) Cranes: Qualification documents (WPS, PQR, and WPQ) in accordance with AWS D14.1/D14.1M.

   (3) Submit for approval to the Contracting Officer two copies of Certified Welder Performance Qualifications (WPQ)and Certified Brazer Performance Qualifications (BPQ) within fifteen calendar days prior to any employee welding on the project material.

   (4) Machinery: Qualification documents (WPS, PQR, and WPQ) in accordance with AWS D14.4/D14.4M.

1.5.2 Previous Qualifications

Welding procedures previously qualified by test may be accepted for this contract without re-qualification, upon receipt of the test results, if the following conditions are met:

a. Testing was performed by an approved testing laboratory, technical consultant, or the Contractor's approved quality control organization.

b. The qualified welding procedure conforms to the requirements of this specification and is applicable to welding conditions encountered under this contract.

c. The welder, welding operator, and tacker qualification tests conform to the requirements of this specification and are applicable to welding conditions encountered under this contract.

1.5.3 Pre-qualified Procedures

Welding procedures which are considered pre-qualified as specified in AWS D1.1/D1.1M will be accepted without further qualification. Submit for approval a listing or an annotated drawing to indicate the joints not pre-qualified. Procedure qualification is mandatory for these joints.

1.5.4 Retests

If welding procedure fails to meet the requirements of AWS D1.1/D1.1M, revise and re-qualify the procedure specification, or at the Contractor's option, welding procedure may be retested in accordance with AWS D1.1/D1.1M. If the welding procedure is qualified through retesting, submit all test results, including those of test welds that failed to meet the requirements, with the welding procedure.

1.5.5 Welder, Welding Operator, and Tacker Qualification

Each welder, welding operator, and tacker assigned to work on this contract shall be qualified in accordance with the applicable requirements of AWS D1.1/D1.1M and as specified in this section. Welders, welding operators, and tackers who make acceptable procedure qualification test welds will be considered qualified for the welding procedure used.

1.5.5.1 Previous Personnel Qualifications

At the discretion of the Contracting Officer, welders, welding operators, and tackers qualified by test within the previous 6 months may be accepted for this contract without re-qualification if all the following conditions are met:

a. Copies of the welding procedure specifications, the procedure qualification test records, and the welder, welding operator, and tacker qualification test records are submitted and approved in accordance with the specified requirements for detail drawings.

b. Testing was performed by an approved testing laboratory, technical consultant, or the Contractor's approved quality control organization.

c. The previously qualified welding procedure conforms to the requirements of this specification and is applicable to welding conditions encountered under this contract.

d. The welder, welding operator, and tacker qualification tests conform to the requirements of this specification and are applicable to welding conditions encountered under this contract.

1.5.5.2 Certificates

Before assigning any welder, welding operator, or tacker to work under this contract, submit the names of the welders, welding operators, and tackers to be employed, and certification that each individual is qualified as specified. State in the certification the type of welding and positions for which the welder, welding operator, or tacker is qualified, the code and procedure under which the individual is qualified, the date qualified, and the name of the firm and person certifying the qualification tests. Keep the certification current, on file, and furnish 3 copies.

1.5.5.3 Renewal of Qualification

Re-qualification of a welder or welding operator is required under any of the following conditions:

a. It has been more than 6 months since the welder or welding operator has used the specific welding process for which he is qualified.

b. There is specific reason to question the welder or welding operator's ability to make welds that meet the requirements of these specifications.

c. The welder or welding operator was qualified by an employer other than those firms performing work under this contract, and a qualification test has not been taken within the past 12 months. Submit as evidence of conformance all records showing periods of employment, name of employer where welder, or welding operator, was last employed, and the process for which qualified.

d. A tacker who passes the qualification test is considered eligible to perform tack welding indefinitely in the positions and with the processes for which he/she is qualified, unless there is some specific reason to question the tacker's ability. In such a case, the tacker is required to pass the prescribed tack welding test.

1.5.6 Inspector Qualification

Inspector qualifications shall be in accordance with AWS D1.1/D1.1M. Qualify all nondestructive testing personnel in accordance with the requirements of ASNT SNT-TC-1A for Levels I or II in the applicable nondestructive testing method. The inspector may be supported by assistant welding inspectors who are not qualified to ASNT SNT-TC-1A, and assistant inspectors may perform specific inspection functions under the supervision of the qualified inspector.

1.5.7 Symbols and Safety

Symbols shall be in accordance with AWS A2.4, unless otherwise indicated. Safe welding practices and safety precautions during welding shall conform to AWS Z49.1.

PART 2 PRODUCTS

2.1 WELDING EQUIPMENT AND MATERIALS

Provide all welding equipment, electrodes, welding wire, and fluxes capable of producing satisfactory welds when used by a qualified welder or welding operator performing qualified welding procedures. All welding equipment and materials shall comply with the applicable requirements of AWS D1.1/D1.1M.

PART 3 EXECUTION

3.1 WELDING OPERATIONS

3.1.1 Requirements

Conform workmanship and techniques for welded construction to the requirements of AWS D1.1/D1.1M and AISC 360. When AWS D1.1/D1.1M and the AISC 360 specification conflict, the requirements of AWS D1.1/D1.1M govern.

3.1.2 Identification

Identify all welds in one of the following ways:

a. Submit written records to indicate the location of welds made by each welder, welding operator, or tacker.

b. Identify all work performed by each welder, welding operator, or tacker with an assigned number, letter, or symbol to identify welds made by that individual. The Contracting Officer may require welders, welding operators, and tackers to apply their symbol next to the weld by means of rubber stamp, felt-tipped marker with waterproof ink, or other methods that do not cause an indentation in the metal. Place the identification mark for seam welds adjacent to the weld at 1 m (3 foot) intervals. Identification with die stamps or electric etchers is not allowed.

3.2 QUALITY CONTROL

Perform testing using an approved inspection or testing laboratory or technical consultant; or if approved, the Contractor's inspection and testing personnel may be used instead of the commercial inspection or testing laboratory or technical consultant. Perform visual, radiographic,and liquid or dye penetrant inspections as necessary to determine conformance with paragraph STANDARDS OF ACCEPTANCE. Conform procedures and techniques for inspection with applicable requirements of AWS D1.1/D1.1M, ASTM E165, ASTM E709, except that in radiographic inspection only film types designated as "fine grain," or "extra fine," are acceptable. Submit a quality assurance plan and records of tests and inspections.

3.3 STANDARDS OF ACCEPTANCE

Conform dimensional tolerances for welded construction, details of welds, and quality of welds with the applicable requirements of AWS D1.1/D1.1M and the contract drawings. Perform nondestructive testing by visual inspection and radiographic,or dye penetrant methods. The minimum extent of nondestructive testing shall be random 50 percent of welds or joints, as indicated on the drawings.

3.3.1 Nondestructive Examination

The welding is subject to inspection and tests in the mill, shop, and field. Inspection and tests in the mill or shop do not relieve the Contractor of the responsibility to furnish weldments of satisfactory quality. When materials or workmanship do not conform to the specification requirements, the Government reserves the right to reject material or workmanship or both at any time before final acceptance of the structure containing the weldment. Submit all records of nondestructive examination in accordance with paragraph "Acceptance Requirements".

3.3.2 Destructive Tests

Make all repairs when metallographic specimens are removed from any part of a structure. Employ only qualified welders or welding operators, and use the proper joints and welding procedures, including peening or heat treatment if required, to develop the full strength of the members and joints cut and to relieve residual stress.

3.4 GOVERNMENT INSPECTION AND TESTING

In addition to the inspection and tests performed by the Contractor for quality control, the Government will perform inspection and testing for acceptance to the extent determined by the Contracting Officer. The costs of such inspection and testing will be borne by the Contractor if unsatisfactory welds are discovered, or by the Government if the welds are satisfactory. The work may be performed by the Government's own forces or under a separate contract for inspection and testing. The Government reserves the right to perform supplemental nondestructive and destructive tests to determine compliance with paragraph STANDARDS OF ACCEPTANCE.

3.5 CORRECTIONS AND REPAIRS

If inspection or testing indicates defects in the weld joints, repair defective welds using a qualified welder or welding operator as applicable. Conduct corrections in accordance with the requirements of AWS D1.1/D1.1M and the specifications. Repair all defects in accordance with the approved procedures. Repair defects discovered between passes before additional weld material is deposited. Wherever a defect is removed and repair by welding is not required, blend the affected area into the surrounding surface to eliminate sharp notches, crevices, or corners. After a defect is thought to have been removed, and before re-welding, examine the area by suitable methods to ensure that the defect has been eliminated. Repaired welds shall meet the inspection requirements for the original welds. Any indication of a defect is regarded as a defect, unless re-evaluation by nondestructive methods or by surface conditioning shows that no unacceptable defect is present.

-- End of Section --

SECTION 05 12 00

STRUCTURAL STEEL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 201	(2006) AISC Certification Program for Structural Steel Fabricators
AISC 303	(2010) Code of Standard Practice for Steel Buildings and Bridges
AISC 325	(2011) Steel Construction Manual
AISC 326	(2009) Detailing for Steel Construction
AISC 341	(2010) Seismic Provisions for Structural Steel Buildings
AISC 360	(2010) Specification for Structural Steel Buildings
AISC 810	(1997) Design Guide 10: Erection Bracing of Low-Rise Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2012) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B46.1	(2009) Surface Texture, Surface Roughness, Waviness and Lay

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A242/A242M	(2004; R 2009) Standard Specification for

	High-Strength Low-Alloy Structural Steel
ASTM A276	(2010) Standard Specification for Stainless Steel Bars and Shapes
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A490	(2012) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A490M	(2012) Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A501	(2007) Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A514/A514M	(2005; R 2009) Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A529/A529M	(2005; R 2009) Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A572/A572M	(2012) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A588/A588M	(2010) Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point, with Atmospheric Corrosion Resistance
ASTM A6/A6M	(2014) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A992/A992M	(2011) Standard Specification for Structural Steel Shapes
ASTM C1107/C1107M	(2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C827/C827M	(2010) Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
ASTM F1554	(2007ae1) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F436	(2011) Hardened Steel Washers
ASTM F436M	(2011) Hardened Steel Washers (Metric)
ASTM F844	(2007a) Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F959	(2009) Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners
ASTM F959M	(2007) Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners (Metric)

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70	(2004) EnviroTop Running and Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes, No. 70

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2000; E 2004) Shop, Field, and Maintenance Painting of Steel
SSPC PS 13.01	(1982; E 2004) Epoxy Polyamide Painting System
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned

	Steel, Type I and Type II
SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926.756	Steel Erection; Beams and Columns

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1002	(2001) Hexagon Head Bolts and Hexagon Head Screws
KS B 1010	(2009) Set of High Strength Hexagon Bolt, Hexagon Nut and Plain Washers for Friction Grip Joints
KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS B 2819	(2005) Sets of torque-shear type high tension bolt, hexagon nut and plain washer for structural joints
KS D 3502	(2007) Dimensions, mass and permissible variations of hot rolled steel sections
KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping
KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 3566	(2009) Carbon Steel Tubes for General Structural Purposes
KS D 3568	(2009) Carbon Steel Square Pipes for General Structural Purposes
KS D 7004	(2008) Covered electrodes for mild steel

1.2 SYSTEM DESCRIPTION

Provide the structural steel system, including shop primer, complete and ready for use. Structural steel systems including design, materials, installation, workmanship, fabrication, assembly, erection, inspection, quality control, and testing shall be provided in accordance with AISC 360 and AISC 341 except as modified in this contract.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication drawings including description of connections; G

SD-03 Product Data

Steel
Bolts, nuts, and washers
Bolts, nuts, and washers

SD-07 Certificates

Welding procedures and qualifications

1.4 SEISMIC PROVISIONS

The structural steel system shall be provided in accordance with AISC 341.

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

Submit fabrication drawings for approval prior to fabrication. Prepare in accordance with AISC 326 and AISC 325. Fabrication drawings shall not be reproductions of contract drawings. Include complete information for the fabrication and erection of the structure's components, including the location, type, and size of bolts, welds, member sizes and lengths, connection details, blocks, copes, and cuts. Double connections that require an erection seat to comply with OSHA 29 CFR 1926.756(c)(1) shall be shown on the shop drawings, reviewed and approved by the structural engineer of record. Use AWS A2.4 standard welding symbols. Member substitutions of details shown on the contract drawings shall be clearly highlighted on the fabrication drawings. Explain the reasons for any deviations from the contract drawings.

1.5.2 Certifications

1.5.2.1 Overhead, Top Running Crane Rail Beam

Submit written field survey results for overhead, top running crane rail beam verifying tolerance requirements, area out of tolerance and proposed corrective measures.

1.5.2.2 Erection Plan

Submit for record purposes. Indicate the sequence of erection, temporary shoring and bracing.

1.5.2.3 Welding Procedures and Qualifications

Prior to welding, submit certification for each welder stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests. If the qualification date of the welding operator is more than one-year old, the welding operator's qualification certificate shall be accompanied by a current certificate by the welder attesting to the fact that he has been engaged in welding since the date of certification, with no break in welding service greater than 6 months.

Conform to all requirements specified in AWS D1.1/D1.1M.

PART 2 PRODUCTS

2.1 STEEL

2.1.1 Structural Steel

ASTM A36/A36M or KS D 3515.

2.1.2 High-Strength Structural Steel

2.1.2.1 Low-Alloy Steel

ASTM A572/A572M.

2.1.2.2 Quenched and Tempered Alloy Steel

ASTM A514/A514M.

2.1.3 Weathering Structural Steel

ASTM A242/A242M, Type 1; ASTM A588/A588M.

2.1.4 Structural Grade Carbon-Manganese Steel

ASTM A529/A529M, high strength carbon-manganese steel of structural quality.

2.1.5 Structural Shapes for Use in Building Framing

Wide flange shapes, ASTM A992/A992M or KS D 3502.

2.1.6 Structural Steel Tubing

ASTM A500/A500M, Grade B; ASTM A501; KS D 3566 or KS D 3568.

2.1.7 Steel Pipe

ASTM A53/A53M, Type E or S, Grade B, weight class STD (Standard), or KS D 3507.

2.2 BOLTS, NUTS, AND WASHERS

Provide the following unless indicated otherwise.

2.2.1 Structural Steel

2.2.1.1 Bolts

ASTM A307 or KS B 1002, Grade A. The bolt heads and the nuts of the supplied fasteners must be marked with the manufacturer's identification mark, the strength grade and type specified by ASTM specifications.

2.2.1.2 Nuts

ASTM A563M, Grade A, heavy hex style, except nuts under M36 may be provided in hex style (ASTM A563, Grade and Style for applicable ASTM bolt standard recommended).

2.2.1.3 Washers

ASTM F844 or KS B 1326 washers for ASTM A307 bolts, and ASTM F436M (ASTM F436) washers for ASTM A325M (ASTM A325) and ASTM A490M (ASTM A490) bolts.

2.2.2 High-Strength Structural Steel

2.2.2.1 Bolts

ASTM A325M (ASTM A325), Type 1 ASTM A490M (ASTM A490), Type 1 or 2, KS B 1010, Class 2, or KS B 2819

2.2.2.2 Nuts

ASTM A563M (ASTM A563), Grade and Style as specified in the applicable ASTM bolt standard, or KS B 1010, Class 2, or KS B 2819.

2.2.2.3 Washers

ASTM F436M (ASTM F436), plain carbon steel, or KS B 1010, or KS B 2819.

2.2.3 Weathering Structural Steel

2.2.3.1 Bolts

ASTM A325M (ASTM A325), Type 3; ASTM A490M (ASTM A490), Type 3.

2.2.3.2 Nuts

ASTM A563M (ASTM A563), heavy hex style, Grade DH3, except Grade C3 may be furnished for ASTM A325M (ASTM A325) bolts, or KS B 1012, hex style.

2.2.3.3 Washers

ASTM F436M (ASTM F436), weathering steel.

2.2.4 Foundation Anchorage

2.2.4.1 Anchor Bolts

ASTM F1554.

2.2.4.2 Anchor Nuts

ASTM A563 (ASTM A563), Grade A, hex style.

2.2.4.3 Anchor Washers

ASTM F844.

2.2.4.4 Anchor Plate Washers

ASTM A36/A36M Stainless steel Type 304 conforming to ASTM A276.

2.2.5 Load Indicator Washers

ASTM F959M (ASTM F959).

2.3 STRUCTURAL STEEL ACCESSORIES

2.3.1 Welding Electrodes and Rods

AWS D1.1/D1.1M or KS D 7004.

2.3.2 Non-Shrink Grout

ASTM C1107/C1107M, with no ASTM C827/C827M shrinkage.

2.3.3 Welded Shear Stud Connectors

AWS D1.1/D1.1M or KS D 7004.

2.4 SHOP PRIMER

SSPC Paint 25, (alkyd primer) or SSPC PS 13.01 epoxy-polyamide, green primer (Form 150) type 1, except provide a Class B coating in accordance with AISC 325 for slip critical joints. Primer shall conform to Federal, State, and local VOC regulations. If flash rusting occurs, re-clean the surface prior to application of primer.

2.5 GALVANIZING

ASTM A123/A123M or ASTM A153/A153M, as applicable, unless specified otherwise galvanize after fabrication where practicable.

2.6 FABRICATION

2.6.1 Markings

Prior to erection, members shall be identified by a painted erection mark. Connecting parts assembled in the shop for reaming holes in field connections shall be match marked with scratch and notch marks. Do not locate erection markings on areas to be welded or on surfaces of weathering steels that will be exposed in the completed structure. Do not locate match markings in areas that will decrease member strength or cause stress concentrations.

2.6.2 Shop Primer

Shop prime structural steel, except as modified herein, in accordance with SSPC PA 1. Do not prime steel surfaces embedded in concrete, galvanized surfaces, surfaces to receive sprayed-on fireproofing, surfaces to receive epoxy coatings, surfaces designed as part of a composite steel concrete section, or surfaces within 13 mm (0.5 inch) of the toe of the welds prior to welding (except surfaces on which metal decking is to be welded). Slip critical surfaces shall be primed with a Class B coating. Prior to assembly, prime surfaces which will be concealed or inaccessible after assembly. Do not apply primer in foggy or rainy weather; when the ambient temperature is below 7 degrees C or over 35 degrees C (45 degrees F or over 95 degrees F); or when the primer may be exposed to temperatures below 4 degrees C (40 degrees F) within 48 hours after application, unless approved otherwise by the Contracting Officer.

2.6.2.1 Cleaning

SSPC SP 6/NACE No.3, except steel exposed in spaces above ceilings, attic spaces, furred spaces, and chases that will be hidden to view in finished construction may be cleaned to SSPC SP 3 when recommended by the shop primer manufacturer. Maintain steel surfaces free from rust, dirt, oil, grease, and other contaminants through final assembly.

2.6.2.2 Primer

Apply primer to a minimum dry film thickness of 0.05 mm (2.0 mil) except provide the Class B coating for slip critical joints in accordance with the coating manufacturer's recommendations. Repair damaged primed surfaces with an additional coat of primer.

2.6.3 Fireproofing and Epoxy Coated Surfaces

Surfaces to receive sprayed-on fireproofing epoxy coatings shall be cleaned and prepared in accordance with the manufacturer's recommendations, and as specified in Section 07 81 00 SPRAY-APPLIED FIREPROOFING.

2.6.4 Surface Finishes

ASME B46.1 maximum surface roughness of 125 for pin, pinholes, and sliding bearings, unless indicated otherwise.

2.7 DRAINAGE HOLES

Adequate drainage holes shall be drilled to eliminate water traps. Hole diameter shall be 13 mm (1/2 inch) and location shall be indicated on the detail drawings. Hole size and location shall not affect the structural integrity.

2.8 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 FABRICATION

Fabrication shall be in accordance with the applicable provisions of AISC 325. Fabrication and assembly shall be done in the shop to the greatest extent possible. The fabricating plant shall be certified under the AISC 201 for structural steelwork.

Compression joints depending on contact bearing shall have a surface roughness not in excess of 13 micrometer (500 micro inch) as determined by ASME B46.1, and ends shall be square within the tolerances for milled ends specified in ASTM A6/A6M.

Structural steelwork, except surfaces of steel to be encased in concrete, surfaces to be field welded, surfaces to be fireproofed, and contact surfaces of friction-type high-strength bolted connections shall be prepared for painting in accordance with endorsement "P" of AISC 201 and primed with the specified paint.

Shop splices of members between field splices will be permitted only where indicated on the Contract Drawings. Splices not indicated require the approval of the Contracting Officer.

3.2 INSTALLATION

3.2.1 Overhead, Top Running Cranes

Do not splice truss top and bottom chords except as approved by the Contracting Officer. Chord splices shall occur at panel joints at approximately the third point of the span. The center of gravity lines of truss members shall intersect at panel points unless otherwise approved by the Contracting Officer. When the center of gravity lines do not intersect at a panel point, provisions shall be made for the stresses due to eccentricity. Cumber of trusses shall be 3 mm (1/8 inch) in 10 feet unless otherwise indicated.

Runway rails and beams shall be provided in accordance with AISC 325 and CMAA 70, except that in case of conflict, the requirements of CMAA 70 shall govern. In addition, provide a maximum vertical difference of 0.8 mm (0.03 inch) in the elevation between adjacent runway rail tops and adjacent runway beam tops at joints. Provide adjustable runway support connections to allow placement of the crane rails and beams to the tolerances specified. Stagger runway rail joints a minimum of one foot, except that the stagger shall not be the same as the crane wheel spacing.

3.3 ERECTION

a. Erection of structural steel, except as indicated in item b. below, shall be in accordance with the applicable provisions of AISC 325. Erection plan shall be reviewed, stamped and sealed by a licensed structural engineer.

b. For low-rise structural steel buildings (18 m(60 feet) tall or less and a maximum of 2 stories), the erection plan shall conform to AISC 303 and the structure shall be erected in accordance with AISC 810.

Provide for drainage in structural steel. After final positioning of steel members, provide full bearing under base plates and bearing plates using nonshrink grout. Place nonshrink grout in accordance with the manufacturer's instructions.

3.3.1 STORAGE

Material shall be stored out of contact with the ground in such manner and location as will minimize deterioration.

3.4 CONNECTIONS

Except as modified in this section, connections not detailed shall be designed in accordance with AISC 360. Build connections into existing work. Do not tighten anchor bolts set in concrete with impact torque wrenches. Punch, subpunch and ream, or drill bolt and pin holes perpendicular to the surface of the member. Holes shall not be cut or enlarged by burning. Bolts, nuts, and washers shall be clean of dirt and rust, and lubricated immediately prior to installation.

3.4.1 Common Grade Bolts

ASTM A307 bolts shall be tightened to a "snug tight" fit. "Snug tight" is the tightness that exists when plies in a joint are in firm contact. If firm contact of joint plies cannot be obtained with a few impacts of an impact wrench, or the full effort of a man using a spud wrench, contact the Contracting Officer for further instructions.

3.4.2 High-Strength Bolts

ASTM A325M (ASTM A325) and ASTM A490M (ASTM A490) bolts shall be fully tensioned to 70 percent of their minimum tensile strength. Provide load indicator bolts or washers in all ASTM A325M (ASTM A325M) or ASTM A490M (ASTM A490) bolted connections, except provide only load indicator washers for slip critical connections. Direct tension indicator tightening, shall be the only acceptable tightening methods. Use only direct tension indicator tightening for slip critical connections. Bolts shall be installed in connection holes and initially brought to a snug tight fit. After the initial tightening procedure, bolts shall then be fully tensioned, progressing from the most rigid part of a connection to the free edges.

3.4.2.1 Installation of Load Indicator Washers (LIW)

ASTM F959M (ASTM F959). Where possible, the LIW shall be installed under the bolt head and the nut shall be tightened. If the LIW is installed adjacent to the turned element, provide a flat ASTM F436M (ASTM F436) washer between the LIW and nut when the nut is turned for tightening, and between the LIW and bolt head when the bolt head is turned for tightening. In addition to the LIW, provide flat ASTM F436M (ASTM F436) washers under both the bolt head and nut when ASTM A490M (ASTM A490) bolts are used.

3.5 GAS CUTTING

Use of gas-cutting torch in the field for correcting fabrication errors will not be permitted on any major member in the structural framing. Use of a gas cutting torch will be permitted on minor members not under stress only after approval has been obtained from the Contracting Officer.

3.6 WELDING

AWS D1.1/D1.1M. Provide AWS D1.1/D1.1M qualified welders, welding operators, and tackers.

The Contractor shall develop and submit the Welding Procedure Specifications (WPS) for all welding, including welding done using prequalified procedures. Prequalified procedures may be submitted for information only; however, procedures that are not prequalified shall be submitted for approval.

3.6.1 Removal of Temporary Welds, Run-Off Plates, and Backing Strips

Remove only from finished areas.

3.7 SHOP PRIMER REPAIR

Repair shop primer in accordance with the paint manufacturer's recommendation for surfaces damaged by handling, transporting, cutting, welding, or bolting.

3.7.1 Field Priming

Field priming of steel exposed to the weather, or located in building areas without HVAC for control of relative humidity. After erection, the field bolt heads and nuts, field welds, and any abrasions in the shop coat shall be cleaned and primed with paint of the same quality as that used for the shop coat.

3.8 GALVANIZING REPAIR

Provide as indicated or specified. Galvanize after fabrication where practicable. Repair damage to galvanized coatings using ASTM A780/A780M zinc rich paint for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces to which repair paint has been applied.

3.9 FIELD QUALITY CONTROL

Perform field tests, and provide labor, equipment, and incidentals required for testing. The Contracting Officer shall be notified in writing of defective welds, bolts, nuts, and washers within 7 working days of the date of weld inspection.

3.9.1 Welds

3.9.1.1 Visual Inspection

AWS D1.1/D1.1M. Furnish the services of AWS-certified welding inspectors for fabrication and erection inspection and testing and verification inspections. Welding inspectors shall visually inspect and mark welds, including fillet weld end returns.

The Contractor shall inspect proper preparation, size, gaging location, and acceptability of welds; identification marking; operation and current characteristics of welding sets in use.

3.9.1.2 Nondestructive Testing

AWS D1.1/D1.1M. Test locations shall be selected by the Contracting Officer. If more than 20 percent of welds made by a welder contain defects identified by testing, then all welds made by that welder shall be tested by radiographic or ultrasonic testing, as approved by the Contracting Officer. When all welds made by an individual welder are required to be tested, magnetic particle testing shall be used only in areas inaccessible to either radiographic or ultrasonic testing. Retest defective areas after repair.

3.9.2 Load Indicator Washers

3.9.2.1 Load Indicator Washer Compression

Load indicator washers shall be tested in place to verify that they have been compressed sufficiently to provide the 0.38 mm (0.015 inch) gap when the load indicator washer is placed under the bolt head and the nut is tightened, and to provide the 0.13 mm (0.005 inch) gap when the load indicator washer is placed under the turned element, as required by ASTM F959M (ASTM F959).

3.9.3 Overhead, Top Running Crane Rails and Beams

Runway rails and beams shall be surveyed (horizontally and vertically) after installation to verify compliance with the tolerance requirements of CMAA 70 and the additional tolerance requirements specified in this section. After each survey, submit a written report to the Contracting Officer with the following information: field survey results, tolerance requirements, areas out of tolerance, and proposed corrective measures. Proposed corrective measures shall be approved by the Contracting Officer. Following completion of corrective measures, areas that were previously out of tolerance shall be re-surveyed and another written report shall be furnished to the Contracting Officer. Field surveys shall be performed and sealed by a registered land surveyor.

3.9.4 High-Strength Bolts

3.9.4.1 Testing Bolt, Nut, and Washer Assemblies

Test a minimum of 3 bolt, nut, and washer assemblies from each mill certificate batch in a tension measuring device at the job site prior to the beginning of bolting start-up. Demonstrate that the bolts and nuts, when used together, can develop tension not less than the provisions specified in AISC 360, depending on bolt size and grade. The bolt tension shall be developed by tightening the nut. A representative of the manufacturer or supplier shall be present to ensure that the fasteners are properly used, and to demonstrate that the fastener assemblies supplied satisfy the specified requirements.

3.9.4.2 Inspection

Inspection procedures shall be in accordance with AISC 360 . Confirm and report to the Contracting Officer that the materials meet the project specification and that they are properly stored. Confirm that the faying surfaces have been properly prepared before the connections are assembled. Observe the specified job site testing and calibration, and confirm that the procedure to be used provides the required tension. Monitor the work to ensure the testing procedures are routinely followed on joints that are specified to be fully tensioned.

Inspection by the Government will include calibration of torque wrenches for high-strength bolts. The Contractor shall inspect calibration of torque wrenches for high-strength bolts.

3.9.4.3 Testing

The Government has the option to perform nondestructive tests on 5 percent of the installed bolts to verify compliance with pre-load bolt tension requirements. The nondestructive testing will be done in-place using an ultrasonic measuring device or any other device capable of determining in-place pre-load bolt tension. The test locations shall be selected by the Contracting Officer. If more than 10 percent of the bolts tested contain defects identified by testing, then all bolts used from the batch from which the tested bolts were taken, shall be tested. Retest new bolts after installation.

-- End of Section --

SECTION 05 21 23

STEEL JOIST GIRDER FRAMING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1/B2.1M	(2009) Specification for Welding Procedure and Performance Qualification
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

STEEL JOIST INSTITUTE (SJI)

SJI LOAD TABLES	(2005; Errata 1 2006; Errata 2 2007; Errata 3 2007) 42nd Edition Catalog of Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders
SJI MANUAL	(2009) 80 Years of Open Web Steel Joist Construction
SJI TD 11	(2007) Technical Digest No. 11 - Design Of Lateral Load Resisting Frames Using Steel Joists and Joist Girders
SJI TD 9	(2008) Technical Digest No. 9 - Handling and Erection of Steel Joists and Joist Girders; 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PS 14.01	(1982; E 2004) Steel Joist Shop Painting System
SSPC Paint 15	(1999; E 2004) Steel Joist Shop Primer

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1200	Hazard Communication
29 CFR 1926	Safety and Health Regulations for Construction
29 CFR 1926.757	Steel Erection; Open Web Steel Joists

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material Safety Data Sheet

SD-02 Shop Drawings

Steel joist girder framing; G

SD-07 Certificates

Welder qualification
Certification of Compliance

1.3 REGULATORY REQUIREMENT

All joist girder framing must conform to 29 CFR 1926.757. Secure all joist bridging and anchoring in place prior to the application of any construction loads. Distribute temporary loads so that joist capacity is not exceeded. Do not apply loads to bridging.

1.4 DELIVERY AND STORAGE

Handle, transport, and store joist girders in a manner to prevent damage affecting their structural integrity. Store all items off the ground in a well drained location protected from the weather and easily accessible for inspection and handling.

1.5 QUALITY ASSURANCE

All work must comply with the requirements set forth in 29 CFR 1926.

1.5.1 Drawing Requirements

Submit steel joist girder framing drawings. Show joist girder type and size, layout in plan, and erection details including methods of anchoring, framing at columns and/or bearing points, type and spacing of bridging, requirements for field welding, and details of accessories as applicable.

1.5.2 Certification of Compliance

Prior to construction commencement, submit Material Safety Data Sheet per 29 CFR 1910.1200 for steel joist girders, and certification for welder qualification, compliance with AWS B2.1/B2.1M, welding operation, and tacker, stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests.

Submit certification of compliance for the following:
SJI MANUAL
SJI TD 9
SJI TD 11

29 CFR 1926
29 CFR 1926.757

PART 2 PRODUCTS

2.1 JOIST GIRDERS AND ACCESSORIES

Provide design data from SJI LOAD TABLES for the joist girders series indicated.

2.2 PAINTING

2.2.1 Shop Painting

Clean and prime joists in accordance with SSPC Paint 15 and SSPC PS 14.01, Steel Joist Shop Painting System, using only Type I, "Red Oxide Paint." Finish coat of paint is specified in Section 09 90 00 PAINTING AND COATING.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Handling and Erection

Conform to SJI LOAD TABLES for the joist girder series indicated.

3.1.2 Welding

All welding must conform to AWS B2.1/B2.1M and AWS D1.1/D1.1M.

3.2 BEARING PLATES

Provide bearing plates to accept full bearing after the supporting members have been plumbed and properly positioned, but prior to placing superimposed loads. The area under the plate must be damp-packed solidly with bedding mortar, except where nonshrink grout is indicated on the drawings. Bedding mortar and grout must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 PAINTING

3.3.1 Touch-Up Painting

After erection of joist girders and joists, touch-up connections and areas of abraded shop coat with paint of the same type used for the shop coat.

3.3.2 Field Painting

Paint joists girders and joists requiring a finish coat in conformance with the requirements of Section 09 90 00 PAINTING AND COATING.

3.4 VISUAL INSPECTIONS

3.4.1 Erection Inspection

AWS D1.1/D1.1M, Section 6. Perform erection inspection and field welding inspections with AWS certified welding inspectors. Welding inspectors must visually inspect and mark welds.

3.5 SCHEDULE

SI dimensioning in this section is based on a mathematical conversion of inch-pound dimensions following the SJI specification SJI LOAD TABLES. The SI and I-P units for the dimensions shown are as follows.

Inch-Pound Units	SI Units
20 feet	6096 mm
30 ksi	207 MPa

-- End of Section --

SECTION 05 30 00

STEEL DECKS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2010) Specification for Structural Steel Buildings

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI D100	(1991; R 2008) Cold-Formed Steel Design Manual
AISI SG03-3	(2002; Suppl 2001-2004; R 2008) Cold-Formed Steel Design Manual Set

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2008; Errata 2008) Structural Welding Code - Sheet Steel

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A1011/A1011M	(2014) Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
ASTM A108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel

ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A792/A792M	(2010) Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
ASTM C423	(2009a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM D1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1149	(2007; R 2012) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber
ASTM D746	(2007) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/
FM DS 1-28	(2002) Design Wind Loads

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

STEEL DECK INSTITUTE (SDI)

SDI 31	(2007) Design Manual for Composite Decks, Form Decks, and Roof Decks
SDI DDMO3	(2004; Errata 2006; Add 2006) Diaphragm Design Manual; 3rd Edition
SDI DDP	(1987; R 2000) Deck Damage and Penetrations
SDI MOC2	(2006) Manual of Construction with Steel Deck

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20	(2002; E 2004) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2010; Change 3) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 209	(2011) Cellular Metal Floor Raceways and Fittings
UL 580	(2006; Reprint Jul 2009) Tests for Uplift Resistance of Roof Assemblies
UL Bld Mat Dir	(2012) Building Materials Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings

SD-03 Product Data

Deck Units
Galvanizing Repair Paint
Mechanical Fasteners
Metal Floor Deck Units
Welding Equipment
Welding Rods and Accessories

SD-05 Design Data

Deck Units

SD-07 Certificates

Welder Qualifications
Powder-Actuated Tool Operator

1.3 QUALITY ASSURANCE

1.3.1 Deck Units

Furnish deck units and accessory products from a manufacturer regularly engaged in manufacture of steel decking. Submit manufacturer's design calculations, or applicable published literature for the structural properties of the proposed deck units.

1.3.2 Certification of Powder-Actuated Tool Operator

Manufacturer's certificate attesting that the operators are authorized to use the low velocity powder-actuated tool.

1.3.3 Qualifications for Welding Work

Follows Welding Procedures in accordance with AWS D1.1/D1.1M. Test specimens shall be made in the presence of Contracting Officer and shall be tested by an approved testing laboratory at the Contractor's expense.

Submit qualified Welder Qualifications in accordance with AWS D1.1/D1.1M, or under an equivalent approved qualification test. Perform tests on test pieces in positions and with clearances equivalent to those actually encountered. If a test weld fails to meet requirements, perform an immediate retest of two test welds until each test weld passes. Failure in the immediate retest will require the welder be retested after further practice or training, performing a complete set of test welds.Submit manufacturer's catalog data for Welding Equipment and Welding Rods and Accessories.

1.3.4 Regulatory Requirements

1.3.4.1 Fire Safety

Test roof deck as a part of a roof deck construction assembly of the type used for this project, listing as fire classified in the UL Bld Mat Dir, or listing as Class I construction in the FM APP GUIDE, and so labeled.

1.3.4.2 Wind Storm Resistance

Provide roof construction assembly capable of withstanding an uplift pressure of 3 kPa (60 pounds per square foot) when tested in accordance with the uplift pressure test described in the FM DS 1-28 or as described in UL 580 and in general compliance with UFC 3-301-01.

1.3.5 Fabrication Drawings

Show type and location of units, location and sequence of connections, bearing on supports, methods of anchoring, attachment of accessories, adjusting plate details, size and location of holes to be cut and reinforcement to be provided, the manufacturer's erection instructions and other pertinent details.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver deck units to the site in a dry and undamaged condition. Store and handle steel deck in a manner to protect it from corrosion, deformation, and other types of damage. Do not use decking for storage or as working platform until units have been fastened into position. Exercise care not to damage material or overload decking during construction. The maximum uniform distributed storage load must not exceed the design live load. Stack decking on platforms or pallets and cover with weathertight ventilated covering. Elevate one end during storage to provide drainage. Maintain deck finish at all times to prevent formation of rust. Repair deck finish using touch-up paint. Replace damaged material.

1.5 DESIGN REQUIREMENTS FOR ROOF DECKS

1.5.1 Properties of Sections

Properties of metal roof deck sections must comply with engineering design width as limited by the provisions of AISI D100.

1.5.2 Allowable Loads

Indicate total uniform dead and live load for detailing purposes.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Steel Sheet

Flat rolled carbon steel sheets of structural quality, thickness not less than 0.75 mm (0.028 inch) before coating, meeting the requirements of AISI SG03-3, except as modified herein. For acoustical steel deck units, provide perforated sheets with 4 mm (5/32 inch) diameter holes staggered 10 mm (3/8 inch) on-centers.

2.1.2 Steel Coating

ASTM A653/A653M designation Z275 (G90) galvanized, or ASTM A792/A792M designation AZ165 (AZ55), aluminum-zinc alloy. Apply coating to both sides of sheet. Conform to UL 209 for coating on decking provided as wire raceways.

2.1.3 Mixes

2.1.3.1 Galvanizing Repair Paint for Floor Decks

Provide a high-zinc-dust content paint to regalvanize welds in galvanized steel conforming to ASTM A780/A780M.

2.1.4 Galvanized Steel Angles for Roof Decks

Provide hot-rolled carbon steel angles conforming to ASTM A36/A36M, merchant quality, Grade Designation SAE/AISI 1023 or SAE/AISI 1025, and hot-dip galvanized in accordance with ASTM A123/A123M.

2.1.5 Joint Sealant Material for Roof Decks

Provide a non-skinning, gun-grade, bulk compound material as recommended by the manufacturer.

2.1.6 Galvanizing Repair Paint for Roof Decks

Provide a high zinc-dust content paint to regalvanize welds in galvanized steel and shall conform to ASTM A780/A780M.

2.1.7 Flexible Closure Strips for Roof Decks

Provide strips made of elastomeric material specified and pre-molded to the configuration required to provide tight-fitting closures at open ends and sides of steel roof decking.

Provide a vulcanized, closed-cell, expanded chloroprene elastomer having approximately 25 kilopascal (3.5 psi) compressive-deflection at 25 percent deflection (limits), conforming to ASTM D1056, Grade No. SCE 41, with the following additional properties:

Brittleness temperature of minus 40 degrees C (minus 40 degrees F) when tested in accordance with ASTM D746.

Flammability resistance with a flame spread rating of less than 25 when tested in accordance with ASTM E84.

Resistance to ozone must be "no cracks" after exposure of a sample kept under a surface tensile strain of 25 percent to an ozone concentration of 100 parts per million of air by volume in air for 100 hours at 40 degrees C (104 degrees F) and tested in accordance with ASTM D1149.

Provide an elastomeric type adhesive with a chloroprene base as recommended by the manufacturer of the flexible closure strips.

2.1.8 Sound Absorbing Material

Provide glass fiber in roll or premolded form for acoustical noncellular steel roof deck and glass fiber rigid strip for acoustical cellular steel deck in accordance with the manufacturer's standards.

2.2 ACCESSORIES

Provide accessories of same material as deck, unless specified otherwise. Provide manufacturer's standard type accessories, as specified.

2.2.1 Adjusting Plates

Provide adjusting plates, or segments of deck units, of same thickness and configuration as deck units in locations too narrow to accommodate full size units. Provide factory cut plates of predetermined size where possible.

2.2.2 End Closures

Fabricated of sheet metal by the deck manufacturer. Provide end closures minimum 0.75 mm (0.028 inch) thick to close open ends at exposed edges of floors, parapets, end walls, eaves, and openings through deck.

2.2.3 Partition Closures

Provide closures for closing voids above interior walls and partitions that are perpendicular to the direction of the configurations. Provide rubber, plastic, or sheet steel closures above typical partitions. Provide minimum one inch thick soft composition rubber closures above walls and partitions contiguous to acoustical steel deck. Provide sheet steel closures above fire-resistant interior walls and partitions located on both sides of wall or partition. Provide glass fiber blanket insulation in the space between pairs of closures at acoustical partitions.

2.2.4 Closure Plates for Composite Deck

Support and retain concrete at each floor level. Provide edge closures at all edges of the slab of sufficient strength and stiffness to support the wet concrete. Provide metal closures for all openings in composite steel deck 6 mm (1/4 inch) and over.

2.2.5 Sheet Metal Collar

Where deck is cut for passage of pipes, ducts, columns, etc., and deck is to remain exposed, provide a neatly cut sheet metal collar to cover edges of deck. Do not cut deck until after installation of supplemental supports.

2.2.6 Cover Plates

Sheet metal to close panel edge and end conditions, and where panels change direction or butt. Polyethylene-coated, self-adhesive, 50 mm (2 inch) wide joint tape may be provided in lieu of cover plates on flat-surfaced decking butt joints.

Fabricate cover plates for abutting floor deck units from the specified structural-quality steel sheets not less than nominal 1.3 millimeter (18 gage) thick before galvanizing. Provide 150 millimeter (6 inch) wide cover plates and form to match the contour of the floor deck units.

2.2.7 Roof Sump Pans

Sump pans must be provided for roof drains and must be minimum 2 mm (0.075 inch) thick steel, recessed type, unless otherwise indicated. Shape sump pans to meet roof slope by the supplier or by a sheet metal specialist. Provide bearing flanges of sump pans to overlap steel deck a minimum of 75 mm (3 inch). Shape, size, and reinforce the opening in bottom of the sump pan to receive roof drain.

2.2.8 Column Closures

Sheet metal, minimum 0.85 mm (0.0358 inch) thick or metal rib lath.

2.2.9 Access Hole Covers

Sheet metal, minimum 1.2 mm (0.0474 inch) thick.

2.2.10 Hanger

Provide clips or loops for utility systems and suspended ceilings of one or more of the following types:

a. Lip tabs or integral tabs where non-cellular decking or flat plate of cellular section is 1.2 mm (0.0474 inch) thick or more, and a structural concrete fill is used over deck.

b. Slots or holes punched in decking for installation of pigtails.

c. Tabs driven from top side of decking and arranged so as not to pierce electrical cells.

d. Decking manufacturer's standard as approved by the Contracting Officer.

2.2.11 Shear Connectors

Provide shear connectors as headed stud type, ASTM A108, Grade 1015 or 1020, cold finished carbon steel with dimensions complying with AISC 360, strap type, ASTM A1011/A1011M, Grade D, hot-rolled carbon steel, or cold-formed, carbon steel powder-actuated mechanical shear connectors.

2.2.12 Mechanical Fasteners

Provide mechanical fasteners, such as powder actuated or pneumatically driven fasteners, for anchoring the deck to structural supports and adjoining units that are designed to meet the loads indicated. Provide positive locking-type fasteners listed by the Steel Deck Institute and ICC-ES, as approved by the Contracting Officer.

2.2.13 Miscellaneous Accessories

Furnish the manufacturer's standard accessories to complete the deck installation. Furnish metal accessories of the same material as the deck and with the minimum design thickness as follows: saddles, 1.204 mm (0.0474 inch) welding washers, 1.519 mm (0.0598 inch) cant strip, 0.749 mm (0.0295 inch) other metal accessories, 0.909 mm (0.0358 inch) unless otherwise indicated. Accessories must include but not be limited to saddles, welding washers, fasteners, cant strips, butt cover plates, underlapping sleeves, and ridge and valley plates.

2.3 FABRICATION

2.3.1 Deck Units

2.3.1.1 Cellular Metal Floor Deck Units

Provide decking as wire raceways conforming to NFPA 70. Fabricate units from the specified structural-quality steel sheets. Provide nominal thickness of the steel sheets, before galvanizing, a minimum 1.3 millimeter (18-gage) for the upper element of the floor deck unit, and a minimum 1.6 millimeter (16-gage) for the lower element of the floor deck unit.

Provide sufficient welds, forming the steel sheets into the cellular floor deck unit, to develop the full horizontal shear at the plane where the steel sheets are joined.

Cellular metal floor deck units must be fluted section cells combined on a flat plate having interlocking type sidelaps. Provide depth, width of unit, number of cells per unit, and width of cells as follows:

DEPTH MINIMUM (millimeter)	WIDTH OF UNIT NOMINAL (millimeter)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (millimeter)
38	600	4	92
38	600	2	245
38	300	1	245
75	600	3	143
75	600	2	245

DEPTH MINIMUM (millimeter)	WIDTH OF UNIT NOMINAL (millimeter)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (millimeter)
75	300	1	245
115	600	4	67
115	600	2	245
115	300	1	245
150	600	2	245
150	300	1	245
190	600	2	245
190	300	1	245

DEPTH MINIMUM (inch)	WIDTH OF UNIT NOMINAL (inch)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (inch)
1-1/2	24	4	3-5/8
1-1/2	24	2	9-5/8
1-1/2	12	1	9-5/8
3	24	3	5-5/8
3	24	2	9-5/8
3	12	1	9-5/8
4-1/2	24	4	2-5/8
4-1/2	24	2	9-5/8
4-1/2	12	1	9-5/8
6	24	2	9-5/8
6	12	1	9-5/8
7-1/2	24	2	9-5/8
7-1/2	12	1	9-5/8

Cellular metal floor deck units must be fluted section cells combined with a matching fluted bottom section having interlocking type sidelaps. Provide depth, width of unit, number of cells per unit, and width of cells as follows:

DEPTH MINIMUM (millimeter)	WIDTH OF UNIT NOMINAL (millimeter)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (millimeter)
75	600	4	92
75	300	1	245
150	600	3	142
DEPTH MINIMUM (inch)	WIDTH OF UNIT NOMINAL (inch)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (inch)
3	24	4	3-5/8
3	12	1	9-5/8
6	12	3	5-5/8

Conform to SDI 31 for deck units. Conform to ASTM A653/A653M, SS, Grade 230, Grade 33; ASTM A1008/A1008M Coated Carbon Steel Sheets, Grade C, 228 mPa (33,000 psi) minimum yield strength; or ASTM A792/A792M Coated Steel Sheets, Grade 33 for formed cellular and non-cellular decking and accessories. Use panels of maximum possible lengths to minimize end laps. Fabricate deck units in lengths to span 3 or more supports with flush, telescoped, or nested 50 mm (2 inch) laps at ends, and interlocking, or nested side laps, unless otherwise indicated. Deck with cross-sectional configuration differing from the units indicated may be used, provided that the properties of the proposed units, determined in accordance with AISI SG03-3, are equal to or greater than the properties of the units indicated and that the material will fit the space provided without requiring revisions to adjacent materials or systems.

2.3.2 Open Beam, Metal Floor Deck Units

Fabricate open beam metal floor deck units of the specified structural-quality steel sheets. Provide nominal thickness of the steel sheets before galvanizing of minimum 1.3 millimeter (18-gage).

Provide open beam metal floor deck units with a fluted section having interlocking type sidelaps. Provide depth, width of unit, number of flutes per unit, and width of flutes as follows:

DEPTH MINIMUM (millimeter)	WIDTH OF UNIT NOMINAL (millimeter)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (millimeter)
38	600	4	92
38	600	2	245

DEPTH MINIMUM (millimeter)	WIDTH OF UNIT NOMINAL (millimeter)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (millimeter)
38	300	1	245
75	600	3	143
75	600	2	245
75	300	1	245
115	600	4	67
115	600	2	245
115	300	1	245
150	600	2	245
150	300	1	245
190	600	2	245
190	300	1	245

DEPTH MINIMUM (inch)	WIDTH OF UNIT NOMINAL (inch)	NUMBER OF CELLS PER UNIT	WIDTH OF CELLS NOMINAL (inch)
1-1/2	24	4	3-5/8
1-1/2	24	2	9-5/8
1-1/2	12	1	9-5/8
3	24	3	5-5/8
3	24	2	9-5/8
3	12	1	9-5/8
4-1/2	24	4	2-5/8
4-1/2	24	2	9-5/8
4-1/2	12	1	9-5/8
6	24	2	9-5/8
6	12	1	9-5/8
7-1/2	24	2	9-5/8
7-1/2	12	1	9-5/8

2.3.3 Length of Floor Deck Units

Provide floor deck units of sufficient length to span three or more spacings where possible.

2.3.4 Roof Deck

Conform to ASTM A792/A792M or ASTM A1008/A1008M for deck used in conjunction with insulation and built-up roofing. Fabricate roof deck units of 0.75 mm (0.0295 inch) design thickness or thicker steel and shop painted or galvanized.

2.3.4.1 Cant Strips for Roof Decks

Fabricate cant strips from the specified commercial-quality steel sheets not less than nominal 0.91 millimeter (0.0359 inch) thick before galvanizing. Bend strips to form a 45-degree cant not less than 125 millimeter (5 inch) wide, with top and bottom flanges a minimum 75 millimeter (3 inch) wide. Length of strips 3000 millimeter (10 feet).

2.3.4.2 Ridge and Valley Plates for Roof Decks

Fabricate plates from the specified structural-quality steel sheets, not less than nominal 0.91 millimeter (0.0359 inch) thick before galvanizing. Provide plates of minimum 120 millimeter (4-1/2 inch) wide and bent to provide tight fitting closures at ridges and valleys. Provide a minimum length of ridge and valley plates of 3000 millimeter (10 feet).

2.3.4.3 Metal Closure Strips for Roof Decks

Fabricate strips from the specified commercial-quality steel sheets not less than nominal 0.91 millimeter (0.0359 inch) thick before galvanizing. Provide strips from the configuration required to provide tight-fitting closures at open ends and sides of steel roof decking.

2.3.5 Form Deck

Conform to ASTM A653/A653M or ASTM A1008/A1008M for deck used as formwork for concrete. Fabricate form deck of 0.38 mm (0.015 inch) design thickness or thicker steel, unless otherwise indicated.. Paint with one coat of manufacture's standard paint.

2.3.6 Composite Deck

Conform to ASTM A653/A653M or ASTM A1008/A1008M for composite deck assembly. Fabricate deck used as the tension reinforcing in composite deck if 0.75 mm (0.0295 inch) design thickness or thicker steel, unless otherwise indicated. 2.3.7 Acoustical Steel Deck

Provide a Noise Reduction Coefficient (NRC) rating of not less than 0.70 , when tested in accordance with ASTM C423, Standard Mounting No. 6. Provide sound absorbing materials with either glass fiber in roll or premolded form for acoustical steel deck (noncellular) or glass fiber rigid strip for acoustical steel deck (cellular) in accordance with manufacturer's standards.

2.3.8 Venting

To ensure positive venting from the underside, provide slotted or perforated steel deck to receive concrete fill, overlay, or a poured concrete deck, if indicated on contract drawings.

2.3.9 Shop Priming

Shop prime accessories and underside of deck at the factory after coating. Clean surfaces in accordance with the manufacturer's standard procedure followed by a spray, dip or roller coat of rust-inhibitive primer, oven cured.

2.3.10 Touch-Up Paint

Provide touch-up paint for shop-painted units of the same type used for the shop painting, and touch-up paint for zinc-coated units of an approved galvanizing repair paint with a high-zinc dust content . Touch-up welds with paint conforming to SSPC Paint 20 in accordance with ASTM A780/A780M. Maintain finish of deck units and accessories by using touch-up paint whenever necessary to prevent the formation of rust.

For floor decking installation, wire brush, clean, and touchup paint the scarred areas on the top and bottom surfaces of the metal floor decking and on the surface of supporting steel members. Include welds, weld scars, bruises, and rust spots for scarred areas. Touched up the galvanized surfaces with galvanizing repair paint. Touch up the painted surfaces with paint for the repair of painted surfaces.

After roof decking installation, wire brush, clean, and touchup paint the scarred areas on top and bottom surfaces of metal roof decking. The scarred areas include welds, weld scars, bruises, and rust spots. Touchup galvanized surfaces with galvanizing repair paint. Touchup painted surfaces with repair paint of painted surfaces.

2.4 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Prior to installation of decking units and accessories, examine worksite to verify that as-built structure will permit installation of decking system without modification.

3.2 INSTALLATION

Install steel deck units in accordance with SDI 31 approved shop drawings. Place units on structural supports, properly adjusted, leveled, and aligned at right angles to supports before permanently securing in place. Damaged deck and accessories including material which is permanently stained or contaminated, deformed, or with burned holes shall not be installed. Extend deck units over three or more supports unless absolutely impractical. Report inaccuracies in alignment or leveling to the Contracting Officer and make necessary corrections before permanently anchoring deck units. Locate deck ends over supports only. Do not use unanchored deck units as a work or storage platform. Permanently anchor units placed by the end of each working day. Do not support suspended ceilings, light fixtures, ducts, utilities, or other loads by steel deck unless indicated. Distribute loads by appropriate means to prevent damage. Prepare shoring in position before concrete placement begins in composite or form deck.

3.2.1 Attachment

Immediately after placement and alignment, and after correcting inaccuracies, permanently fasten steel deck units to structural supports and to adjacent deck units by welding with normal 16 mm (5/8 inch) diameter puddle welds or fastened with screws, powder-actuated fasteners, or pneumatically driven fasteners as indicated on the design drawings and in accordance with manufacturer's recommended procedure and SDI 31. Clamp or weight deck units to provide firm contact between deck units and structural supports while performing welding or fastening. Anchoring the deck to structural supports with powder-actuated fasteners or pneumatically driven fasteners is prohibited. Attachment of adjacent deck units by button-punching is prohibited.

3.2.1.1 Welding

Perform welding in accordance with AWS D1.3/D1.3M using methods and electrodes recommended by the manufacturers of the base metal alloys being used. Ensure only operators previously qualified by tests prescribed in AWS D1.1/D1.1M and AWS D1.3/D1.3M make welds. Immediately recertify, or replace qualified welders, that are producing unsatisfactory welding. Conform to the recommendations of the Steel Deck Institute and the steel deck manufacturer for location, size, and spacing of fastening. Do not use welding washers at the connections of the deck to supports. Do not use welding washers at sidelaps. Holes and similar defects will not be acceptable. Attach all partial or segments of deck units to structural supports in accordance with Section 2.5 of SDI DDMO3. Attach shear connectors as shown and welded as per AWS D1.1/D1.1M through the steel deck to the steel member. Immediately clean welds by chipping and wire brushing. Heavily coat welds, cut edges and damaged portions of coated finish with zinc-dust paint conforming to ASTM A780/A780M or shop primed finish with the manufacturer's standard touch-up paint.

3.2.1.2 Fastening

Anchor deck to structural supports and adjoining units with mechanical fasteners as listed by the Steel Deck Institute, ICC-ES, the fastener and steel deck manufacturers, and approved by the Contracting Officer. Drive the powder-actuated fasteners with a low-velocity piston tool by an operator authorized by the manufacturer of the powder-actuated tool. Drive pneumatically fasteners with a low-velocity fastening tool and comply with the manufacturer's recommendations.

3.2.1.3 Fastening Floor Deck Units

Fasten floor deck units to the steel supporting members at ends and at all intermediate supports, both parallel and perpendicular to deck span, by welds. Do not exceed spacing of welds of 300 millimeter (12 inch) on center, with a minimum of two welds per floor deck unit at each support. Provide 20 millimeter (3/4 inch) minimum diameter fusion welds. Coordinate welding sequence and procedure with the placing of the floor deck units. Blow holes shall be cause for rejection.

Lock sidelaps between adjacent floor deck units together at intervals not exceeding 1220 millimeter (48 inch) on center by welding or button punching for all spans.

3.2.2 Openings

Cut or drill all holes and openings required and be coordinated with the drawings, specifications, and other trades. Frame and reinforce openings through the deck in conformance with SDI DDP. Reinforce holes and openings 150 to 300 mm (6 to 12 inch) across by 1.204 mm (0.0474 inch) thick steel sheet at least 300 mm (12 inch) wider and longer than the opening and be fastened to the steel deck at each corner of the sheet and at a maximum of 150 mm (6 inch) on center. Reinforce holes and openings larger than 300 mm (12 inch) by steel channels or angles installed perpendicular to the steel joists and supported by the adjacent steel joists. Install steel channels or angles perpendicular to the deck ribs and fasten to the channels or angles perpendicular to the steel joists. Deck manufacturer shall approve holes or openings larger than 150 mm (6 inch) in diameter prior to drilling or cutting. Openings must not interfere with seismic members such as chords and drag struts.

3.2.3 Deck Damage

SDI MOC2, for repair of deck damage.

3.2.4 Accessory Installation

3.2.4.1 Adjusting Plates

Provide in locations too narrow to accommodate full-size deck units and install as shown on shop drawings.

3.2.4.2 End Closures

Provide end closure to close open ends of cells at columns, walls, and openings in deck.

3.2.4.3 Closures Above Partitions

Provide for closing voids between cells over partitions that are perpendicular to direction of cells. Provide a one-piece closure strip for partitions 100 mm (4 inch) nominal or less in thickness and two-piece closure strips for wider partitions. Provide sheet metal closures above fire-rated partitions at both sides of partition with space between filled with fiberglass insulation. Provide flexible rubber closures above acoustic-rated partitions at both sides of partition with space between filled with blanket insulation.

3.2.4.4 Cover Plates

Provide metal cover plates, or joint tape, at joints between cellular decking sheets to be used as electrical raceways. Where concrete leakage would be a problem, provide metal cover plates, or joint tape, at joints between decking sheets, cellular or non-cellular, to be covered with concrete fill.

3.2.4.5 Column Closures

Provide for spaces between floor decking and columns which penetrate the deck. Field cut closure plate to fit column in the field and tack weld to decking and columns.

3.2.4.6 Access Hole Covers

Provide to seal holes cut in decking to facilitate welding of decking to structural supports.

3.2.4.7 Hangers

Provide as indicated to support utility system and suspended ceilings. Space devices so as to provide one device per 0.60 square meters (6.25 square feet).

3.2.5 Sound Absorbing Material

Install sound absorbing glass fiber roll or premolded form, neatly in voids between perforated webs of acoustical noncellular steel deck and glass fiber rigid strip, in cells of acoustical cellular steel deck. Keep sound absorbing material dry before, during and after installation.

3.2.6 Concrete Work

Prior to placement of concrete, inspect installed decking to ensure that there has been no permanent deflection or other damage to decking. Replace decking which has been damaged or permanently deflected as approved by the Contracting Officer. Place concrete on metal deck in accordance with Construction Practice of SDI 31.

3.2.7 Preparation of Fire-Proofed Surfaces

Provide deck surfaces, both composite and non-composite, which are to receive sprayed-on fireproofing, galvanized and free of all grease, mill oil, paraffin, dirt, salt, and other contaminants which impair adhesion of the fireproofing. Complete any required cleaning prior to steel deck installation using a cleaning method that is compatible with the sprayed-on fireproofing.

3.3 JOINT SEALING FOR ROOF DECKS

Seal sidelaps and endlaps with manufacturer's recommended joint sealing material and shop or field apply the material. Before applying the sealing material, completely remove dust, dirt, moisture, and other foreign material from the surfaces to which the sealing material is to be applied. Apply sealing material in strict accordance with the sealing material manufacturer's printed instructions.

3.4 ROOF SUMP PANS

Place sump pans over openings in roof decking and fusion welded to top surface of roof decking. Do not exceed spacing of welds of 300 millimeter (12 inch) with not less than one weld at each corner. Field cut opening in the bottom of each roof sump pan to receive the roof drain as part of the work of this section.

3.5 CANT STRIPS FOR ROOF DECKS

Provide strips to be fusion welded to surface of roof decking, secured to wood nailers by galvanized screws or to steel framing by galvanized self-tapping screws or welds. Do not exceed spacing of welds and fasteners of 300 millimeter (12 inch). Lap end joints a minimum 75 millimeter (3 inch) and secure with galvanized sheet metal screws spaced a maximum 100 millimeter (4 inch) on center.

3.6 RIDGE AND VALLEY PLATES FOR ROOF DECKS

Provide plates to be fusion welded to top surface of roof decking. Lap end joints a minimum 75 millimeter (3 inch). For valley plates, provide endlaps to be in the direction of water flow.

3.7 CLOSURE STRIPS FOR ROOF DECKS

Provide closure strips at open, uncovered ends and edges of the roof decking and in voids between roof decking and top of walls and partitions where indicated. Install closure strips in position in a manner to provide a weathertight installation.

3.8 ROOF INSULATION SUPPORT FOR ROOF DECKS

Provide metal closure strips for support of roof insulation where rib openings in top surface of metal roof decking occur adjacent to edges and openings. Weld metal closure strips in position.

3.9 CLEANING AND PROTECTION FOR ROOF DECKS

Upon completion of the deck, sweep surfaces clean and prepare for installation of the roofing.

3.10 FIELD QUALITY CONTROL

3.10.1 Decks Not Receiving Concrete

Inspect the decking top surface for distortion after installation. For roof decks not receiving concrete, verify distortion by placing a straight edge across three adjacent top flanges. The maximum allowable gap between the straight edge and the top flanges is 2 mm (1/16 inch); when gap is more than 2 mm (1/16 inch), provide corrective measures or replacement. Re-inspect decking after performing corrective measures or replacement.

-- End of Section --

SECTION 05 50 13

MISCELLANEOUS METAL FABRICATIONS
05/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 303	(2010) Code of Standard Practice for Steel Buildings and Bridges

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE A10.3	(2006) Operations - Safety Requirements for Powder Actuated Fastening Systems

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.21.1	(2009) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)
ASME B18.21.2M	(1999; R 2005) Lock Washers (Metric Series)
ASME B18.22M	(1981; R 2010) Metric Plain Washers
ASME B18.6.2	(1998; R 2010) Slotted Head Cap Screws, Square Head Set Screws, and Slotted

	Headless Set Screws: Inch Series
ASME B18.6.3	(2010) Machine Screws, Tapping Screws, and Machine Drive Screws (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A283/A283M	(2003; R 2007) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A467/A467M	(2007) Standard Specification for Machine Coil Chain
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A475	(2003; R 2009e1) Standard Specification for Zinc-Coated Steel Wire Strand
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A786/A786M	(2005; R 2009) Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel

	Floor Plates
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B108/B108M	(2014) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM C1513	(2012) Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections
ASTM D1187/D1187M	(1997; R 2011e1) Asphalt-Base Emulsions for Use as Protective Coatings for Metal
ASTM D2047	(2011) Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
ASTM E488	(1996; R 2003) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM E 814	(2010) Standard Test Method for Fire Tests of Through-Penetration Fire Stops
ASTM F1267	(2012) Metal, Expanded, Steel

MASTER PAINTERS INSTITUTE (MPI)

MPI 79	(Oct 2009) Alkyd Anti-Corrosive Metal Primer

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MBG 531	(2009) Metal Bar Grating Manual
NAAMM MBG 532	(2009) Heavy Duty Metal Bar Grating Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2013) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1016	(1997) Foundation Bolts
KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping
KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 3541	(2008) Carbon Steel Plates for Pressure Vessels for Low Temperature Service
KS D 3566	(2009) Carbon Steel Tubes for General Structural Purposes
KS D 3568	(2009) Carbon Steel Square Pipes for General Structural Purposes
KS D 3601	(2008) Expanded Metals
KS D 4311	(2010) Ductile Iron Pipes
KS D 6701	(2012) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6759	(2011) Aluminum and Aluminum Alloy Extruded Shapes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication drawings; G

SD-03 Product Data

Cover plates and frames

Floor gratings and roof walkways

Wheel guards

Window and door guards

Roof hatch

1.3 QUALIFICATION OF WELDERS

Qualify welders in accordance with AWS D1.1/D1.1M. Use procedures, materials, and equipment of the type required for the work.

1.4 DRAWINGS

1.4.1 Installation Drawings

Submit templates, erection and installation drawings indicating thickness, type, grade, class of metal, and dimensions. Show construction details, reinforcement, anchorage, and installation with relation to the building construction for the following items.

a. Access doors and panels.

b. Cover plates and frames.

c. Expansion joint covers.

d. Floor gratings and roof walkways.

e. Wheel guards.

f. Window and door guards.

g. Embedded angles and plates.

h. Roof hatch.

1.4.2 Fabrication Drawings

Submit fabrication drawings showing layout(s), connections to structural system, and anchoring details as specified in AISC 303 for the following items:

a. Structural steel door frames

b. Roof hatch

1.5 DELIVERY, STORAGE, AND PROTECTION

Protect from corrosion, deformation, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Structural Carbon Steel

ASTM A36/A36M or KS D 3515.

2.1.2 Structural Tubing

ASTM A500/A500M; or KS D 3568.

2.1.3 Steel Pipe

ASTM A53/A53M, Type E or S, Grade B, or KS D 3507.

2.1.4 Fittings for Steel Pipe

Standard malleable iron fittings ASTM A47/A47M; or KS D 4311.

2.1.5 Gratings

a. Gray cast iron ASTM A48/A48M, Class 40.

b. Metal plank grating, non-slip requirement, aluminum ASTM B209M (ASTM B209), 6061-T6 or KS D 6701; steel ASTM A653/A653M, Z275 (G90), or KS D 3506.

c. Metal bar type grating NAAMM MBG 531 or NAAMM MBG 532.

2.1.6 Floor Plates, Patterned

Floor plate ASTM A786/A786M. Steel plate shall not be less than 1.9 mm (14 gage).

2.1.7 Anchor Bolts

ASTM A307 or KS B 1016. Where exposed, shall be of the same material, color, and finish as the metal to which applied.

2.1.7.1 Expansion, Sleeve, and Adhesive Anchors

Provide anchors with minimum concrete or masonry embedment as indicated. Design values listed shall be as tested according to ASTM E488.

a. Minimum pullout value shall be as indicated.

b. Minimum shear value shall be as indicated.

2.1.7.2 Lag Screws and Bolts

ASME B18.2.1, type and grade best suited for the purpose.

2.1.7.3 Toggle Bolts

ASME B18.2.1.

2.1.7.4 Bolts, Nuts, Studs and Rivets

ASME B18.2.2 or ASTM A307 or KS B 1016.

2.1.7.5 Powder Actuated Fasteners

Follow safety provisions of ASSE/SAFE A10.3.

2.1.7.6 Screws

ASME B18.2.1, ASME B18.6.2, ASME B18.6.3 and ASTM C1513.

2.1.7.7 Washers

Provide plain washers to conform to ASME B18.22M (ASME B18.21.1). Provide beveled washers for American Standard beams and channels, square or rectangular, tapered in thickness, and smooth. Provide lock washers to conform to ASME B18.21.2M (ASME B18.21.1).

2.1.8 Aluminum Alloy Products

Conform to ASTM B209M (ASTM B209), KS D 6701, or KS D 6701 for sheet plate, ASTM B221M (ASTM B221), KS D 6759, or KS D 6759 for extrusions and ASTM B26/B26M or ASTM B108/B108M for castings, as applicable. Provide aluminum extrusions at least 3 mm (1/8 inch) thick and aluminum plate or sheet at least 1.3 mm (0.050 inch) thick.

2.2 FABRICATION FINISHES

2.2.1 Galvanizing

Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing: ASTM A123/A123M, ASTM A153/A153M, ASTM A653/A653M, ASTM A924/A924M, Z275 (G90), or KS D 3506 as applicable.

2.2.2 Galvanize

Anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

2.2.3 Repair of Zinc-Coated Surfaces

Repair damaged surfaces with galvanizing repair method and paint conforming to ASTM A780/A780M or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Contracting Officer. Clean areas to be repaired and remove slag from welds. Heat surfaces to which stick or paste material is applied, with a torch to a temperature sufficient to melt the stick or paste; spread molten material uniformly over surfaces to be coated and wipe off excess material.

2.2.4 Shop Cleaning and Painting

2.2.4.1 Surface Preparation

Blast clean surfaces in accordance with SSPC SP 6/NACE No.3. Surfaces that will be exposed in spaces above ceiling or in attic spaces, crawl spaces, furred spaces, and chases may be cleaned in accordance with SSPC SP 3 in lieu of being blast cleaned. Wash cleaned surfaces which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean. Steel to be embedded in concrete shall be free of dirt and grease. Do not paint or galvanize bearing surfaces, including contact surfaces within slip critical joints, but coat with rust preventative applied in the shop.

2.2.4.2 Pretreatment, Priming and Painting

Apply pretreatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of 0.03 mm (1.0 mil). Tint additional prime coat with a small amount of tinting pigment.

2.2.5 Nonferrous Metal Surfaces

Protect by plating, anodic, or organic coatings.

2.2.6 Aluminum Surfaces

2.2.6.1 Surface Condition

Before finishes are applied, remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.

2.2.6.2 Aluminum Finishes

Unexposed sheet, plate and extrusions may have mill finish as fabricated. Sandblast castings' finish, medium, AA DAF45. Unless otherwise specified, provide all other aluminum items with a standard mill finish. Provide a coating thickness not less than that specified for protective and decorative type finishes for items used in interior locations or architectural Class I type finish for items used in exterior locations in AA DAF45. Provide a polished satin finish on items to be anodized.

2.3 ACCESS DOORS AND PANELS

Provide flush type access doors and panels unless otherwise indicated. Fabricate frames for access doors of steel not lighter than 1.9 mm (14 gage) with welded joints and anchorage for securing into construction. Provide access doors with a minimum of 350 by 500 mm (14 by 20 inches) and of not lighter than 1.9 mm (14 gage) steel, with stiffened edges and welded attachments. Provide access doors hinged to frame and with a flush-face, turn-screw-operated latch. Provide exposed metal surfaces with a shop applied prime coat, unless otherwise indicated.

Provide ceiling access panels for terminal air blenders as indicated. Provide pin-tumbler cylinder locks with appropriate cams in lieu of screwdriver-operated latches.

2.4 CONTROL-JOINT COVERS

Provide control-joint covers to be located on wall surfaces of concrete, masonry and tile work. Provide protective coating on the surface in contact with concrete, masonry or tile.

2.5 CORNER GUARDS AND SHIELDS

For jambs and sills of openings and edges of platforms provide steel shapes and plates anchored in masonry or concrete with welded steel straps or end-weld stud anchors. Form corner guards for use with glazed or ceramic tile finish on walls with 1.6 mm (0.0625 inch) thick corrosion-resisting steel with polished or satin finish, extend 1.5 m (5 feet) above the top of cove base or to the top of the wainscot, whichever is less, and securely anchor to the supporting wall. Corner guards on exterior shall be galvanized.

2.6 COVER PLATES AND FRAMES

Fabricate cover plates of 6 mm (1/4 inch) thick rolled steel weighing not more than 45 kg (100 pounds) per plate with a slip-resistant, carbon steel conforming to ASTM A283/A283M or KS D 3541 having a minimum static coefficient of friction of 0.50 when tested in accordance with ASTM D2047. On wearing surfaces provide aluminum oxide or silicon carbide. Plate shall be galvanized. Reinforce to sustain expected live load indicated on contract drawings. Frames shall be structural steel shapes and plates, securely fastened to the structure as indicated. Miter and weld all corners. Butt joint straight runs. Allow for expansion on straight runs over 4500 mm (15 feet). Provide holes for lifting tools, flush drop handles for removal formed from 6 mm (1/4 inch) round stock where indicated, and holes and openings with 13 mm (1/2 inch) clearance for pipes and equipment, as indicated. Remove sharp edges and burrs from cover plates and exposed edges of frames. Weld all connections and grind top surface smooth. Weld bar stops every (six 150 mminches). Provide 3 mm (1/8 inch) clearance at edges and between cover plates.

2.7 EXPANSION JOINT COVERS

Provide expansion joint covers constructed of extruded aluminum with anodized satin aluminum finish for walls and ceilings and with standard mill finish for floor covers and exterior covers. Furnish plates, backup angles, expansion filler strip and anchors as indicated. Provide expansion joint system with fire rating as indicated.

2.8 EXTRUDED FLOOR MAT FRAMES

Provide recess frames for roll-up floor mats of extruded 6063-T5 aluminum, in sizes shown. Miter corners to ensure accurate fitting. Determine depth of recess by the mat thickness. Anchor frames in concrete with anchor pins or bolts. Provide roll-up mats of aluminum construction with carpet, vinyl, serrated aluminum, or abrasive surface. Provide roll-up mats for use in recessed area. Show construction details of recessed areas on the drawings.

2.9 FLOOR GRATINGS AND ROOF WALKWAYS

Design steel or aluminum grating in accordance with NAAMM MBG 531 for bar type grating or manufacturer's charts for plank grating. Galvanize steel floor gratings.

a. Design floor gratings to support a stress (live load) of 12.0 KPa (250 pounds per square foot) for the spans indicated, with maximum deflection of L/240.

b. NAAMM MBG 531, band edges of grating with bars of the same size as the bearing bars. Weld banding in accordance with the manufacturer's standard for trim unless otherwise indicated. Design tops of bearing bars, cross or intermediate bars to be in the same plane and match grating finish.c. Anchor gratings to structural members with bolts, toggle bolts, or expansion shields and bolts, unless otherwise indicated.

d. Slip resistance requirements must exceed both wet and dry a static coefficient of friction of 0.5.

e. Rooftop walkway: Minimum 600 mm (2 feet) wide, 1.8 mm (14 gage), ASTM A653/A653M, Z275 (G-90), steel with slip resistant surface. Furnish all brackets, connectors and other accessories. Support at minimum 1500 mm (5 foot) intervals on hard rubber pads in accordance with manufacturer's instructions.

2.10 GAS-TIGHT MANHOLE COVER AND FRAME

Provide a heavy duty type made of ductile cast-iron with bolted lid, machined bearing surfaces and gasket grooves, continuous neoprene gasket, counter sunk bronze hex head cap screws, and concealed watertight pickholes. Provide frame with a 760 mm (30 inch) diameter clear opening. Maximum weight of frame and cover together to be 240 kg (530 pounds).

2.11 GUARD POSTS (BOLLARDS/PIPE GUARDS)

Provide 200 mm (8 inch) diameter galvanized weight steel pipe as specified in ASTM A53/A53M or KS D 3566, unless otherwise indicated. Anchor posts in concrete and fill solidly with concrete with minimum compressive strength of 17 MPa (2500 psi).

2.12 MISCELLANEOUS PLATES AND SHAPES

Provide for items that do not form a part of the structural steel framework, such as lintels, sill angles, miscellaneous mountings and frames. Provide lintels fabricated from structural steel shapes over openings in masonry walls and partitions as required to support wall loads over openings. Provide with connections and fasteners. Construct to have at least 200 mm (8 inches) bearing on masonry at each end.

Provide angles and plates, ASTM A36/A36M, for embedment as indicated. Galvanize embedded items exposed to the elements according to ASTM A123/A123M.

2.13 SAFETY CHAINS

Construct safety chains of galvanized steel, straight link type, 5 mm (3/16 inch) diameter, with at least twelve links per 300 mm (one foot), and with snap hooks on each end. Test safety chain in accordance with ASTM A467/A467M, Class CS. Provide snap hooks of boat type. Provide galvanized 10 mm (3/8 inch) bolt with 20 mm (3/4 inch) eye diameter for attachment of chain, anchored as indicated. Supply two chains, 100 mm (4 inches) longer than the anchorage spacing, for each guarded area. Locate safety chain where indicated. Mount the top chain 1050 mm (3.5 feet) above the floor and mount the lower chain 600 mm (2 feet) above the floor.

2.14 SECURITY GRILLES

Fabricate of channel frames with not less than two masonry anchors at each jamb and 12 mm (1/2 inch) hardened steel bars spaced not over 100 mm (4 inches) both ways and welded to frame. Provide 18 by 16 mesh screen and two layers of 6 mm (1/4 inch) hardware cloth clamped to frame.

2.15 STEEL PLATE WAINSCOTS FOR CONCRETE OR MASONRY COLUMNS

Shop bend to radius for round columns and at right angles for square and rectangular columns with slight 6 mm (1/4 inch) radius on corners, with no horizontal joints and not more than 2 vertical joints single strapped and butt welded with a thickness of the plate.

2.16 STRUCTURAL STEEL DOOR FRAMES

Provide frames of rolled shapes as indicated. Miter and weld heads to jambs, or have riveted clip angle connections concealed in the finished work. Provide frames for swinging doors with 16 by 40 mm (5/8 by 1 1/2 inch) solid bar stops secured to the frame by welding or by 6 mm (1/4 inch) diameter countersunk machine screws spaced not more than 300 mm (12 inches) on centers. Stiffen head openings greater than 900 mm (3 feet) sufficient to limit deflection to not more than 2 mm (1/16 inch). Secure frames to masonry with zinc-coated metal anchors spaced not more than 750 mm (30 inches) on centers. Where necessary to engage the threads of machine screws for fastening hardware, back frames on inside faces with steel plates of suitable thickness; tap frames and reinforcing plates as necessary for the installation of hardware and other work. Countersink rivets and screw heads where exposed in the finished work. Grind welds smooth.

2.17 WHEEL GUARDS

Provide wheel guards of hollow, heavy-duty type cast iron conforming to ASTM A48/A48M, with shaped, rounded top, at least 450 mm (18 inches) high, and designed to provide a minimum of 150 mm (6 inches) of protection.

2.18 WINDOW AND DOOR GUARDS, DIAMOND-MESH TYPE

Provide diamond-mesh window and door guards constructed of woven steel wire or expanded metal framed with hot-rolled or cold-formed structural steel shapes. Provide woven wire panels of 3.3 mm (10 gage), 40 mm (1 1/2 inch) mesh secured through weaving bar to 25 by 12 by 3 mm (one by 1/2 by 1/8 inch) thick channel frame. Miter and weld corners of frames. Provide expanded metal panels conforming to ASTM F1267 or KS D 3601. Mount window and door guards, 38 mm (1-1/2 inches) width, on interior of window and door frame with not less than two tamperproof hinged butts mounted on wood jambs with 6 mm (1/4 inch) lag bolts, to masonry jamb with toggle bolts, or welded to metal jambs. Mount window and door guards on exterior of window frame with not less than two tamperproof hinged butts mounted on 25 by 12 by 3 mm (one by 1/2 by 1/8 inch)jamb channel attached as indicated to 50 by 6 mm (2 by 1/4 inch)plate anchored to wood jamb with 6 mm (1/4 inch) lag bolts; to masonry jamb with toggle bolts, or to concrete jambs and solid masonry jambs with expansion shields and bolts. Provide one additional butt for each 900 mm (3 foot) internal length of guard over 1500 mm (5 feet). Provide one tamperproof hasp and padlock, with access from the interior, for each butt used and installed on the jamb opposite to that hinged.

2.19 WINDOW AND DOOR GUARDS, WOVEN WIRE

Provide woven wire window and door guards of size necessary to completely fill opening. Construct guards with 10 mm (3/8 inch) round rod frame and

40 mm (1 1/2 inch) diamond-mesh of No. 10 U.S. Gage (3.4 mm) (0.135 inch) diameter wire; all material zinc-coated. Provide at least three hinge side clips on one side and two lock ring hasps on opposite side.

2.20 CHIMNEYS, VENTS, AND SMOKESTACKS

Design and construct chimneys and vents in accordance with NFPA 211. Form chimney connectors of not lighter than 1.01 mm (20 gauge) galvanized steel. Design and construct stacks to withstand a wind velocity of 130 km/h (80 mile/h) in accordance with ASCE 7. Construct unlined stacks of black-steel plates not less than 5 mm (3/16 inch) thick conforming to ASTM A36/A36M. Weld seams and joints, except provide an angle flange for connection to the boiler, other equipment, and stack support.

2.21 CLEANOUT DOORS

Provide galvanized cleanout doors with frames, and unless otherwise indicated sized to match flues. Provide a continuous flange and anchors for securing frames into masonry. The doors shall be smoke-proof, hinged, and have fastening devices to hold the door closed.

2.22 COAL-HOPPER DOORS

Construct coal-hopper doors of galvanized steel plates and shapes and complete with frame, stops, wall box, hinges, and hasp or lock-type latch. Weld joints and attachments.

2.23 DOWNSPOUT BOOTS

Provide cast iron downspout boots with receiving bells sized to fit downspouts.

2.24 FOUNDATION VENTS

Provide foundation vents of the same size as the masonry units or sized as indicated, and made of extruded aluminum with integral water stop and sliding interior closer or damper operable from the outside. Provide an insect screen at the back of the vent. Provide Louvered openings with top and bottom drip lips, and the net ventilating area with closer or damper open at least 35 percent of the gross wall opening. The frames shall have a structural strength adequate to permit use in masonry walls without a lintel.

2.25 GUY CABLES

Guy cables shall be pre-stretched, galvanized wire rope of the sizes indicated. Wire rope shall conform to ASTM A475, high strength grade with Class A coating. Guys shall have a factory attached clevis top-end fitting; a factory attached open-bridge strand socket bottom-end fitting; and be complete with oval eye, threaded anchor rods. Fittings and accessories shall be hot-dip galvanized.

2.26 WINDOW SUB-SILL

Provide window sub-sill of extruded aluminum alloy with size and design indicated. Provide not less than two anchors per window section for securing into mortar joints of masonry sill course. Provide sills for banks of windows with standard mill finish with a protective coating, prior to shipment, of two coats of a clear, colorless, methacrylate lacquer applied to all surfaces of the sills.

2.27 WINDOW WELLS

Window wells shall be not lighter than 1.5 mm (16 gauge) corrugated sheet steel, hot-dip galvanized after fabrication with top edge of walls having a 19 mm (3/4 inch) bead or rolled top. Window wells shall be semicircular or semielliptical in form and shall overlap the window by at least 75 mm (3 inches) on each side. Removable cover, hot-dip galvanized after fabrication, consisting of steel bar grate with bars spaced at not more than 50 mm (2 inch) centers and welded to 25 by 6 mm (1 by 1/4 inch) frame shall be designed to fit into and rest on top edge of window well.

2.28 FIRE EXTINGUISHER CABINETS

Cabinets to be located in fire-rated walls shall be fire-rated type, fabricated in accordance with ASTM E 814, and shall be listed by an approved testing agency for 1- and 2-hour combustible and non-combustible wall systems. The testing agency's seal shall be affixed to each fire-rated cabinet. Cabinets shall be of the recessed type suitable for 4.5 kg (10 pound) extinguishers, or other size as indicated. Box and trim shall be of heavy gage rolled steel. Door shall be a rigid frame with full length piano type hinge and double strength (DSA) glass panel. Door and panel shall have the manufacturer's standard white baked enamel finish inside and out.

2.29 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Install items at locations indicated, according to manufacturer's instructions. Verify all measurements and take all field measurements necessary before fabrication. Exposed fastenings shall be compatible materials, shall generally match in color and finish, and harmonize with the material to which fastenings are applied. Include materials and parts necessary to complete each item, even though such work is not definitely shown or specified. Poor matching of holes for fasteners shall be cause for rejection. Conceal fastenings where practicable. Thickness of metal and details of assembly and supports shall provide strength and stiffness. Form joints exposed to the weather shall be formed to exclude water. Items listed below require additional procedures.

3.2 WORKMANSHIP

Provide miscellaneous metalwork that is well formed to shape and size, with sharp lines and angles and true curves. Drilling and punching shall produce clean true lines and surfaces. Provide continuous welding along the entire area of contact except where tack welding is permitted. Do not tack weld exposed connections of work in place and ground smooth. Provide a smooth finish on exposed surfaces of work in place and unless otherwise approved, flush exposed riveting. Mill joints where tight fits are required. Corner joints shall be coped or mitered, well formed, and in true alignment. Accurately set work to established lines and elevations and securely fastened in place. Install in accordance with manufacturer's installation instructions and approved drawings, cuts, and details.

3.3 ANCHORAGE, FASTENINGS, AND CONNECTIONS

Provide anchorage where necessary for fastening miscellaneous metal items securely in place. Include for anchorage not otherwise specified or indicated slotted inserts, expansion shields, and powder-driven fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish, to which fastenings are applied. Conceal fastenings where practicable.

3.4 BUILT-IN WORK

Form for anchorage metal work built-in with concrete or masonry, or provide with suitable anchoring devices as indicated or as required. Furnish metal work in ample time for securing in place as the work progresses.

3.5 WELDING

Perform welding, welding inspection, and corrective welding, in accordance with AWS D1.1/D1.1M. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation.

3.6 FINISHES

3.6.1 Dissimilar Materials

Where dissimilar metals are in contact, protect surfaces with a coat conforming to MPI 79 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete, plaster, mortar, masonry, wood, or absorptive materials subject to wetting, protect with ASTM D1187/D1187M, asphalt-base emulsion.

3.6.2 Field Preparation

Remove rust preventive coating just prior to field erection, using a remover approved by the rust preventive manufacturer. Surfaces, when assembled, shall be free of rust, grease, dirt and other foreign matter.

3.6.3 Environmental Conditions

Do not clean or paint surface when damp or exposed to foggy or rainy weather, when metallic surface temperature is less than minus 15 degrees C (5 degrees F) above the dew point of the surrounding air, or when surface temperature is below 7 degrees C (45 degrees F) or over 35 degrees C (95 degrees F), unless approved by the Contracting Officer.

3.7 ACCESS PANELS

Install a removable access panel not less than 300 by 300 mm (12 by 12 inches) directly below each valve, flow indicator, damper, or air splitter that is located above the ceiling, other than an acoustical ceiling, and that would otherwise not be accessible.

3.8 CONTROL-JOINT COVERS

Provide covers over control-joints and fasten on one side only with fasteners spaced to give positive contact with wall surfaces on both sides of joint throughout the entire length of cover.

3.9 COVER PLATES AND FRAMES

Install the tops of cover plates and frames flush with floor.

3.10 WHEEL GUARDS

Anchor guards to concrete or masonry in accordance with manufacturer's instructions. Fill hollow cores solid with concrete with minimum compressive strength of 17 MPa (2500 psi).

3.11 ROOF HATCH (SCUTTLES)

Provide aluminum or zinc-coated steel sheets not less than 1.9 mm (14 gage), with 75 mm (3 inch) beaded flange, welded and ground at corner. Provide a minimum clear opening of 760 by 900 mm (30 by 36 inches). Construction and accessories as follows:

a. Insulate cover and curb with 25 mm (one inch) thick rigid fiberboard insulation covered and protected by aluminum sheet or zinc-coated steel liner not less than 0.45 mm (26 gage) with 300 mm (12 inches) high curb, formed with 75 mm (3 inch) mounting flange with holes provided for securing to the roof deck. Equip the curb with an integral metal cap flashing of the same gage and metal as the curb, full welded and ground at corners for weather tightness.

b. Provide hatch completely assembled with pintle hinges, compression spring operators enclosed in telescopic tubes, positive snap latch with turn handles on inside and outside, and neoprene draft seal. Provide fasteners for padlocking on the inside. Equip the cover with an automatic hold-open arm complete with grip handle to permit one-hand release. Cover action shall be smooth through its entire range with an operating pressure of approximately 130 N (30 pounds).

3.12 INSTALLATION OF CHIMNEYS, VENTS, AND SMOKESTACKS

Install chimneys and vents in accordance with NFPA 211. Provide a cleanout opening with a tight-fitting, hinged, cast-iron door and frame at the base of each smokestack. Provide a top band on stacks for attachment of painter's rigging. Provide roof housing, rain cap, downdraft diverter, fire damper, and other accessories required for a complete installation. Join sections of prefabricated lined stacks with acid-resisting high-temperature cement and steel draw bands. Provide means to prevent accumulation of water in the smokestack.

3.13 DOOR GUARD FRAME

Mount door guard frame over the glazed opening using 6 mm (1/4 inch) lag bolts on the interior of wood doors or tamperproof through bolts on the interior of metal doors.

3.14 INSTALLATION OF GUARD POSTS (BOLLARDS/PIPE GUARDS)

Set pipe guards vertically in concrete piers. Construct piers of, and the hollow cores of the pipe filled with, concrete having a compressive strength of 21 MPa (3000 psi).

3.15 INSTALLATION OF DOWNSPOUT BOOTS

Secure downspouts to building through integral lips with appropriate fasteners.

3.16 RECESSED FLOOR FRAMES & MATS

Verify field measurements prior to releasing materials for fabrication by the manufacturer. Use a mat frame to ensure recess accuracy in size, shape and depth. Form drain pit by blocking out concrete when frames are installed, damp proof after concrete has set. Assemble frames onsite and install so that upper edge will be level with finished floor surface. Screed the concrete base inside the mat recess frame area using the edge provided by the frame as a guide and anchor into the cement with anchor pins a minimum of 610 mm (24 inches) on centers.

3.17 MOUNTING OF SAFETY CHAINS

Mount safety chains 1070 mm (3 feet 6 inches) and 610 mm (2 feet) above the floor.

3.18 STRUCTURAL STEEL DOOR FRAMES

Secure door frames to the floor slab by means of angle clips and expansion bolts. Weld continuous door stops to the frame or tap screwed with countersunk screws at no more than 450 mm (18 inch) centers, assuring in either case full contact with the frame. Make any necessary reinforcements and drill and tap the frames as required for hardware.

3.19 INSTALLATION OF WHEEL GUARDS

Fill wheel guards with concrete and anchor to the floor or the building according to the manufacturer's recommendations.

3.20 BAR-GRILLE WINDOW GUARDS

Securely anchor bar-grille window guards to masonry with 13 mm (1/2 inch) diameter prison-type screws or bolts and expansion shields, or other type of fastenings if the ends of such fastenings are welded to the adjoining metal grilles or otherwise made tamperproof in a satisfactory manner. Spanner-head screws or bolts are not considered prison-type fasteners.

3.21 DIAMOND MESH WINDOW AND DOOR GUARDS

Unless otherwise indicated, mount diamond mesh window guards on exterior of window frame with not less than two tamperproof hinged butts mounted on 25 by 300 by 3 mm (1 by 12 by 1/8 inch) jamb channel attached as indicated to 50 by 6 mm (2 by 1/4 inch) plate anchored to wood jamb with 6 mm (1/4 inch) lag bolt, to masonry jamb with toggle bolts, or to concrete jambs and solid masonry jambs with expansion shields and bolts. Provide one additional butt for each 900 mm (3 foot) internal length of guard over 1500 mm (5 feet). Install hasp and padlock on the jamb opposite to that hinged.

3.22 INSTALLATION OF WINDOW WELLS

Place window wells as shown with the walls securely anchored to foundation surface. Excavate the area within the well to the bottom of the well and covered with a 100 mm (4 inch) thick layer of coarse gravel or crushed rock.

-- End of Section --

SECTION 05 50 14

STRUCTURAL METAL FABRICATIONS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA ADM	(2010) Aluminum Design Manual

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

ANSI/AGMA 2005	(2003D; R 2008) Design Manual for Bevel Gears
ANSI/AGMA 6001	(2008E) Design and Selection of Components for Enclosed Gear Drives

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2008) Structural Welding Code - Aluminum

ASME INTERNATIONAL (ASME)

ASME B4.1	(1967; R 2009) Preferred Limits and Fits for Cylindrical Parts
ASME B46.1	(2009) Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)

ASTM A380	(2006) Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A490	(2012) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A490M	(2012) Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)
ASTM A514/A514M	(2005; R 2009) Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B177/B177M	(2011) Standard Guide for Engineering Chromium Electroplating
ASTM B766	(1986; R 2008) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM D962	(1981; R 2008e1) Aluminum Powder and Paste Pigments for Paints
ASTM E165	(2009) Standard Test Method for Liquid Penetrant Examination
ASTM E446	(2010) Radiographs for Steel Castings Up to 2 In. (51mm) in Thickness
ASTM E709	(2008) Standard Guide for Magnetic Particle Examination
ASTM E94	(2004; R 2010) Radiographic Examination

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Welding of Structural Steel
Structural Steel Welding Repairs; G
Materials List

SD-06 Test Reports

Tests, Inspections, and Verifications

SD-07 Certificates

Qualification of Welders and Welding Operators
Application Qualification for Steel Studs
Welding of Aluminum; G

1.3 QUALITY ASSURANCE

1.3.1 Qualification of Welders and Welding Operators

Certify that the qualification of welders and welding operators and tack welders who will perform structural steel welding have been qualified for the particular type of work to be done in accordance with the requirements of AWS D1.1/D1.1M, Section 4, or ASME BPVC SEC IX, Section IX, prior to commencing fabrication.

a. List the qualified welders by name and specify the code and procedures under which qualified and the date of qualification within the certification. Prior qualification will be accepted if welders have performed satisfactory work under the code for which qualified within the preceding three months. Welders are required to repeat the qualifying tests when their work indicates a reasonable doubt as to proficiency. Those passing the requalification tests will be recertified. Those not passing will be disqualified until passing. Contractor incurs all expenses in connection with qualification and requalification.

b. Perform welding of aluminum conforming to AA ADM or AWS D1.2/D1.2M, Sections 1 through 7, 9 and 10. The welding process and welding operators shall be prequalified as required by AWS D1.2/D1.2M, Section 5 or AA ADM, Subsection 7.2.4 in accordance with the methods described in ASME BPVC SEC IX, Section IX. Furnish for approval a certified report giving the results of the qualifying tests, and a complete schedule of the welding process for each aluminum fabrication to be welded prior to commencing fabrication prior to commencing welding.

c. Maintain an approved inspection system and perform required inspections in accordance with Contract Clause CONTRACTOR INSPECTION SYSTEM. Welding will be subjected to inspection to determine conformance with the requirements of AWS D1.1/D1.1M, the approved welding procedures and provisions stated in other sections of these specifications.

1.3.2 Detail Drawings

Submit detail drawings for metalwork and machine work, prior to fabrication, include within the detail drawings catalog cuts, templates, fabrication and assembly details and type, grade and class of material as appropriate. Elements of fabricated items inadvertently omitted on contract drawings shall be detailed by the fabricator and indicated on the detail drawings.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Materials List

Submit a list of the materials to be used in the fabrication of each item at the time of submittal of detail drawings.

2.2 FABRICATION

2.2.1 Structural Fabrication

Material shall be straight before being laid off or worked. Perform straightening, if necessary, by methods that will not impair the metal. Sharp kinks or bends will be cause for rejection of the material. Material with welds will not be accepted except where welding is definitely specified, indicated or otherwise approved. Make bends using approved dies, press brakes or bending rolls. Where heating is required, take precautions to avoid overheating the metal and allow it to cool in a manner that will not impair the original properties of the metal. Proposed flame cutting of material, other than structural steel, will be subject to approval and shall be indicated on detail drawings. Shearing shall be accurate and all portions of the work neatly finished. Corners shall be square and true unless otherwise shown. Re-entrant cuts shall be filleted to a minimum radius of 19 mm (3/4 inch) unless otherwise approved. Provide finished members free of twists, bends and open joints. Bolts, nuts and screws shall be tight.

2.2.1.1 Dimensional Tolerances for Structural Work

Measure dimensions using an approved calibrated steel tape of approximately the same temperature as the material being measured. The overall dimensions of an assembled structural unit shall be within the tolerances indicated on the drawings or as specified in the particular section of these specifications for the item of work. Where tolerances are not specified in other sections of these specifications or shown, an allowable variation of 1 mm (1/32 inch) is permissible in the overall length of component members with both ends milled; component members without milled ends shall not deviate from the dimensions shown by more than 2 mm (1/16 inch) for members 9 m (30 feet) or less in length, and by more than 3 mm (1/8 inch) for members over 9 m (30 feet) in length.

2.2.1.2 Structural Steel Fabrication

Structural steel may be cut by mechanically guided or hand-guided torches, provided an accurate profile with a surface that is smooth and free from cracks and notches is obtained. Prepare surfaces and edges in accordance with AWS D1.1/D1.1M, Subsection 3.2. Where structural steel is not to be welded, chipping or grinding will not be required except as necessary to remove slag and sharp edges of mechanically guided or hand-guided cuts not exposed to view. Chip, grind or machine to sound metal hand-guided cuts which are to be exposed or visible.

2.2.1.3 Structural Aluminum Fabrication

Lay out and cut aluminum in accordance with the AA ADM, Section 6.

2.2.2 Welding

2.2.2.1 Welding of Structural Steel

a. Welding Procedures for Structural Steel - Prequalify welding procedures for structural steel as described in AWS D1.1/D1.1M, Subsection 3.1 or qualify by tests as prescribed in AWS D1.1/D1.1M, Section 4. Properly documented evidence of compliance with all requirements of these specifications for previous qualification tests shall establish a welding procedure as prequalified. For welding procedures qualified by tests, the test welding and specimen testing will be witnessed and the test report document signed by the Contracting Officer. Approval of any welding procedure will not relieve the Contractor of the responsibility for producing a finished structure meeting all requirements of these specifications. The Contractor will be directed or authorized to make any changes in previously approved welding procedures that are deemed necessary or desirable by the Contractor Officer. Submit a complete schedule of welding procedures for each steel structure to be welded prior to commencing fabrication. The schedule shall conform to the requirements specified in the provisions AWS D1.1/D1.1M, Sections 2, 3, 4, 6, 7 and applicable portions of Section 8. Provide within the schedule detailed procedure specifications and tables or diagrams showing the procedures to be used for each required joint. Include in the welding procedures filler metal, preheat, interpass temperature and stress-relief heat treatment requirements. Each welding procedure shall be clearly identified as being prequalified or required to be qualified by tests. Welding procedures shall show types and locations of welds designated or in the specifications to receive nondestructive examination.

b. Welding Process - Perform welding of structural steel by an electric arc welding process using a method which excludes the atmosphere from the molten metal and conforms to the applicable provisions of AWS D1.1/D1.1M. Minimize residual stresses, distortion and shrinkage from welding.

c. Welding Technique

(1) Filler Metal - The electrode, electrode-flux combination and grade of weld metal shall conform to the appropriate AWS specification for the base metal and welding process being used or be as shown where a specific choice of AWS specification allowable is required. Include the AWS designation of the electrodes to be used in the schedule of welding procedures. Use only low hydrogen electrodes for manual shielded metal-arc welding regardless of the thickness of the steel. Use a controlled temperature storage oven at the job site as prescribed by AWS D1.1/D1.1M, Subsection 3.5 to maintain low moisture of low hydrogen electrodes.

(2) Preheat and Interpass Temperature - Perform preheating as required by AWS D1.1/D1.1M, Subsection 3.5 or as otherwise specified except that the temperature of the base metal shall be at least 20 degrees C (70 degrees F). Slowly and uniformly preheat welds by approved means to the prescribed temperature, held at that temperature until the welding is completed and then permitted to cool slowly in still air.

(3) Stress-Relief Heat Treatment - Where stress relief heat treatment

is specified or shown, perform in accordance with the requirements of AWS D1.1/D1.1M, Subsection 5.8 unless otherwise authorized or directed.

d. Workmanship - Perform welding workmanship in accordance with AWS D1.1/D1.1M, Section 3 and other applicable requirements of these specifications.

(1) Preparation of Base Metal - Prior to welding inspect surfaces to be welded to ensure compliance with AWS D1.1/D1.1M, Subsection 3.2.

(2) Temporary Welds - Make temporary welds, required for fabrication and erection, under the controlled conditions prescribed for permanent work. Make temporary welds using low-hydrogen welding electrodes and by welders qualified for permanent work as specified in these specifications. Conduct preheating for temporary welds as required by AWS D1.1/D1.1M for permanent welds except that the minimum temperature shall be 50 degrees C (120 degrees F) in any case. In making temporary welds, arcs shall not be struck in other than weld locations. Remove each temporary weld and grind flush with adjacent surfaces after serving its purpose.

(3) Tack Welds - Subject tack welds that are to be incorporated into the permanent work to the same quality requirements as the permanent welds; clean and thoroughly fuse them with permanent welds. Perform preheating as specified above for temporary welds. Multiple-pass tack welds shall have cascaded ends. Remove defective tack welds before permanent welding.

2.2.2.2 Welding of Steel Castings

Remove unsound material from the surfaces of steel castings, to be incorporated into welded connections, by chipping, machining, air-arc gouging or grinding. Do not weld major connections designed for transfer of stresses if the temperature of the casting is lower than 40 degrees C (100 degrees F). Castings containing over 0.35 percent carbon or over 0.75 percent manganese shall be preheated to a temperature not to exceed 230 degrees C (450 degrees F) and conduct welding while the castings are maintained at a temperature above 180 degrees C (350 degrees F). Welding will not be permitted on castings containing carbon in excess of 0.45 percent except on written authorization. Castings requiring welding repairs after the first annealing and castings involving welding fabrication shall be stress-relieved annealed prior to receiving final machining unless otherwise permitted.

2.2.2.3 Welding of Steel Studs

Conform to the requirements of AWS D1.1/D1.1M, Section 7, except as otherwise specified for the procedures for welding steel studs to structural steel, including mechanical, workmanship, technique, stud application qualification, production quality control and fabrication and verification inspection procedures.

a. Application Qualification for Steel Studs - As a condition of approval of the stud application process, furnish certified test reports and certification that the studs conform to the requirements of AWS D1.1/D1.1M, Subsections 7.2 and 7.3, certified results of the stud manufacturer's stud base qualification test, and certified results of the stud application qualification test as required by AWS D1.1/D1.1M, Subsection 7.6, prior to commencing fabrication, except as otherwise specified.

b. Production Quality Control - Conform to the requirements of AWS D1.1/D1.1M, Subsection 7.7, except as otherwise specified for quality control for production welding of studs. Studs on which pre-production testing is to be performed shall be welded in the same general position as required on production studs (flat, vertical, overhead or sloping). If the reduction of the length of studs becomes less than normal as they are welded, stop welding immediately and do not resume until the cause has been corrected.

2.2.3 Bolted Connections

2.2.3.1 Bolted Structural Steel Connections

Provide bolts, nuts and washers of the type specified or indicated. Equip all nuts with washers except for high strength bolts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where the use of high strength bolts is specified or indicated, the materials, workmanship and installation shall conform to the applicable provisions of ASTM A325M (ASTM A325) or ASTM A490M (ASTM A490).

a. Bolt holes shall be accurately located, smooth, perpendicular to the member and cylindrical.

b. Holes for regular bolts shall be drilled or sub-drilled and reamed in the shop and not be more than 2 mm (1/16 inch) larger than the diameter of the bolt.

c. Holes for fitted bolts shall be match-reamed or drilled in the shop. Remove burrs resulting from reaming. Keep bolt threads entirely outside of the holes. The body diameter of bolts shall have tolerances as recommended by ASME B4.1for the class of fit specified. Place fitted bolts in reamed holes by selective assembly to provide an LN-2 fit.

d. Holes for high strength bolts shall not have diameters more than 2 mm (1/16 inch) larger than bolt diameters. If the thickness of the material is not greater than the diameter of the bolts, the holes may be punched. If the thickness of the material is greater than the diameter of the bolts the holes may be drilled full size or sub-punched or sub-drilled at least 3 mm (1/8 inch) smaller than the diameter of the bolts and then reamed to full size. Poor matching of holes will be cause for rejection. Drifting occurring during assembly shall not distort the metal or enlarge the holes. Reaming to a larger diameter of the next standard size bolt will be allowed for slight mismatching.

2.2.3.2 Bolted Aluminum Connections

Conform to the requirements of AA ADM, Section 6 for punching, drilling, reaming and bolting for bolted aluminum connections.

2.2.4 Riveted Connections

2.2.4.1 Riveted Structural Steel Connections

a. Rivet Holes - Rivet holes shall be accurately spaced, cylindrical, perpendicular to the member and 2 mm (1/16 inch) larger than the diameter of the rivet. Countersinking shall be true and square with the hole. If the thickness of the material is not greater than the diameter of the rivet, the holes may be punched full size. If the thickness of the material is greater than the diameter of the rivet, drill the holes full size or sub-punched or sub-drilled at least 3 mm (1/8 inch) smaller than the diameter of the rivet and then reamed to full size in accordance with the following provisions unless otherwise specified or authorized. For shop connections, rivet holes may be drilled full size if the component parts to be riveted are welded, bolted or clamped together before drilling of rivet holes. For field connections the holes required to be sub-punched or sub-drilled shall be reamed in the shop if the work is assembled and matchmarked in the shop. For field connections not assembled in the shop, the holes required to be sub-punched or sub-drilled will be reamed in the field after the work has been assembled and bolted together.

(1) Punched Holes - Punching shall be accurate. The diameter of the punch is not to be more than 2 mm (1/16 inch) greater than the diameter of the rivet. The diameter of the die opening is not to be more than 2 mm (1/16 inch) greater than the diameter of the punch. Holes shall be clean cut without torn or ragged edges.

(2) Reamed and Drilled Holes - Reaming and final drilling is to be done with the component parts of the member assembled and firmly fastened together. Use twist drills for drilling. Use short taper reamers having not less than four flutes for reaming. Make reamed holes smooth by the reamer touching the entire circumference of the hole. Remove outside burrs on reamed holes to the extent of making a 2 mm (1/16 inch) chamfer.

(3) Accuracy of Punched and Drilled Holes - The accuracy of holes punched or drilled full size shall be such that for assembled components with a group of contiguous holes in the same plane 75 percent of the holes will admit a rod equal to the diameter of the cold rivet at right angles to the plane of the connection. The accuracy of holes required to be reamed or drilled after assembly will be such that any group of contiguous holes in the same plane shows no offset greater than 1 mm (1/32 inch) between adjacent thicknesses of metal. Drifting to enlarge holes is not allowed. Poor matching of holes will be cause for rejection. Reaming to a larger diameter for the next standard size rivet will be allowed for slight mismatching.

b. Driving Rivets - Pin and firmly draw together with bolts all components to be riveted before commencing. Heat Rivets uniformly to a light cherry red color at a temperature not over 1070 degrees C (1950 degrees F) in a gas, oil or electric furnace constructed so that it can be adjusted to the proper temperature except that an approved coal or coke furnace may be used for heating field rivets. Do not drive rivets after their temperature falls below 540 degrees C (1000 degrees F). When heated and ready for driving, rivets shall be free from slag, scale and adhesive materials. Hot drive rivets with pressure tools. Completely fill the holes with driven rivets. Neatly form rivet heads with dies of approved shape and full size, concentric with the rivet hole and in full contact with the member. Remove loose, burned, badly formed or otherwise defective rivets and replace with care to avoid damage to adjacent metal. Recupping or caulking will not be permitted. Chip or grind flush countersunk rivet with the surface of the plate unless otherwise specified or authorized. Do not paint field rivets until they have been inspected and accepted.

2.2.4.2 Riveted Aluminum Connections

Conform to the requirements of AA ADM, Section 6 for punching, drilling, reaming and riveting for riveted aluminum connections.

2.2.5 Patterns

Take care to avoid sharp corners or abrupt changes in cross section; ample fillets are to be used in the construction of patterns. Add, as required, draft and increases in pattern thicknesses to conform to the standard foundry practice applied and as necessary to ensure that all metal thicknesses of the finished castings conform to the dimensions shown and are within the tolerances specified in paragraph INSPECTION OF STEEL CASTINGS.

2.2.6 Castings

Each casting and castings weighing more than 225 required kg (500 required pounds) shall bear cast or stamped heat numbers. Deviations from the dimensions of castings shown shall not exceed amounts that will impair the strength of castings by more than 10 percent as computed from the dimensions shown. Dimensions of castings shown on approved detail drawings are finished dimensions. Castings that are warped or otherwise distorted or that are oversize to an extent that will interfere with proper fit with other parts of the machinery or structure will be rejected. The structure of metal in castings shall be homogeneous and free from excessive nonmetallic inclusions. Excessive segregation of impurities or alloys at critical points in castings will be cause for rejection. Do not make repairs to castings prior to approval. Minor surface imperfections not affecting the strength of casting may be welded in the "green" if approved. Surface imperfections will be considered minor when the depth of the cavity prepared for welding is the lesser of 20 percent of the actual wall thickness or 25 mm (1 inch). Defects other than minor surface imperfections may be welded only when specifically authorized in accordance with the following requirements:

a. The defects have been entirely removed and are judged not to affect the strength, use or machineability of the castings when properly welded and stress relieved.

b. The proposed welding procedure, stress relief and method of examination of the repair work have been submitted and approved.

2.2.7 Machine Work

Tolerances, allowances and gauges for metal fits between plain, non-threaded, cylindrical parts shall conform to ASME B4.1 for the class of fit shown or required unless otherwise shown on approved detail drawings. Where fits are not shown they will be suitable as approved. Tolerances for machine-finished surfaces designated by non-decimal dimensions shall be within 400 µm (1/64 inch). Sufficient machining stock will be allowed on placing pads to ensure true surfaces of solid material. Provide finished contact or bearing surfaces true and exact to secure full contact. Polish journal surfaces and finish all surfaces with sufficient smoothness and accuracy to ensure proper operation when assembled. Parts entering any machine shall be accurately machined and all like parts be interchangeable except that parts assembled together for drilling or reaming of holes or machining will not be required to be interchangeable with like parts. Accurately locate all drilled holes bolts.

2.2.7.1 Finished Surfaces

Provide surface finishes, indicated or specified, in accordance with ASME B46.1. Values of required roughness heights are arithmetical average deviations expressed in micrometers (microinches). These values are maximum. Lesser degrees will be satisfactory unless otherwise indicated. Compliance with surface requirements shall be determined by sense of feel and visual inspection of the work compared to Roughness Comparison Specimens in accordance with the provisions of ASME B46.1. Values of roughness width and waviness height shall be consistent with the general type of finish specified by roughness height. Where the finish is not indicated or specified use that which is most suitable for the particular surface, provide the class of fit required and be indicated on the detail drawings by a symbol which conforms to ASME B46.1 when machine finishing is provided. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable for the intended use will be cause for rejection.

2.2.7.2 Unfinished Surfaces

Lay out all work to secure proper matching of adjoining unfinished surfaces unless otherwise directed. Where there is a large discrepancy between adjoining unfinished surfaces chip and grind smooth or machine to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown and be chipped or ground free of all projections and rough spots. Fill in depressions or holes not affecting the strength or usefulness of the parts in an approved manner.

2.2.7.3 Pin Holes

Pin holes are to be bored true to gauges, smooth, straight and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position.

2.2.7.4 Gears

Provide gears that have machine cut teeth of a form conforming to applicable design requirements of ANSI/AGMA 2005 and ANSI/AGMA 6001 unless otherwise specified or shown.

2.2.7.5 Shafting

Turn or grind shafting with hot-rolled or cold-rolled steel, as required, unless otherwise specified or authorized. Provide fillets where changes in section occur. Cold-finished shafting may be used where keyseating is the only machine work required.

2.2.7.6 Bearings

Bearings may be lined with babbitt or bronze unless otherwise specified or shown. Where the bearing pressure is in excess of 1400 kPa (200 psi), bearings shall be lined with bronze. Pressures on lined bearings shall not exceed 2000 kPa (300 psi) of projected area unless otherwise required or authorized. Anti-friction bearings of approved types and of sizes not less than those recommended by the bearing manufacturer for the duty intended will be permitted subject to approval. Properly align all bearings provided with a suitable means of lubrication. Install anti-friction bearings as required to provide for retention of the lubricant and to exclude dirt and grit.

2.2.8 Miscellaneous Provisions

2.2.8.1 Metallic Coatings

a. Zinc Coatings - Apply zinc coatings in a manner and of a thickness and quality conforming to ASTM A123/A123M. Where zinc coatings are destroyed by cutting, welding or other causes regalvanize the affected areas. Regalvanize coatings 50 g (2 ounces) or heavier with a suitable low-melting zinc base alloy similar to the recommendations of the American Hot-Dip Galvanizers Association to the thickness and quality specified for the original zinc coating. Repair coatings less than 50 g (2 ounces) in accordance with ASTM A780/A780M.

b. Cadmium Coatings - Provide cadmium coatings of a quality and thickness conforming to the requirements of ASTM B766 and inspections conforming to the requirements of ASTM E165.

c. Chromium Coatings - Apply chromium coatings for engineering in conformance with ASTM B177/B177M.

2.2.8.2 Cleaning of Corrosion-Resisting Steel

Remove oil, paint and other foreign substances from corrosion-resisting steel surfaces after fabrication. Perform cleaning by vapor degreasing or by the use of cleaners of the alkaline, emulsion or solvent type. After the surfaces have been cleaned give a final rinsing with clean water followed by a 24 hour period during which the surfaces are intermittently wet with clean water and then allowed to dry for the purpose of inspecting the clean surfaces. Visually inspect the surfaces for evidence of paint, oil, grease, welding slag, heat treatment scale, iron rust or other forms of contamination. If evidence of foreign substance is found, clean again in accordance with the applicable provisions of ASTM A380. Furnish the proposed method of treatment for approval. Visually re-inspect after treatment. Use only stainless steel or nonmetallic bristle brushes to remove foreign substances. Any contamination occurring subsequent to the initial cleaning shall be removed by one or more of the methods indicated above.

2.2.8.3 Lubrication

The arrangement and details for lubrication shall be as shown. Thoroughly clean and lubricate, with an approved lubricant, all bearing surfaces before erection or assembly.

2.2.9 Shop Assembly

Assemble each machinery and structural unit furnished in the shop to determine the correctness of the fabrication and matching of the component parts unless otherwise specified. Do not exceed those tolerances shown. Closely check each unit assembled to ensure that all necessary clearances have been provided and that binding does not occur in any moving part. Assembly in the shop shall be in the same position as final installation in the field unless otherwise specified. Perform assembly and disassembly work in the presence of the Contracting Officer unless waived in writing. Immediately remedy errors or defects disclosed by the Contractor without cost to the Government. Before disassembly for shipment each piece of a machinery or structural unit shall be match-marked to facilitate erection in the field. Indicate the location of match-marks by circling with a ring of white paint after the shop coat of paint has been applied or as otherwise directed.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Perform material tests and analyses certified by an approved laboratory to demonstrate that materials are in conformity with the specifications. These tests and analyses shall be performed and certified at the Contractor's expense. Perform tests, inspections, and verifications conforming to the requirements of the particular sections of these specifications for the respective items of work unless otherwise specified or authorized. Conduct tests in the presence of the Contracting Officer if so required. Submit certified test reports for materials with all materials delivered to the site.

2.3.1 Nondestructive Testing

When doubt exists as to the soundness of any material part, such part may be subjected to any form of nondestructive testing determined by the Contracting Officer. This may include ultrasonic, magnaflux, dye penetrant, x-ray, gamma ray or any other test that will thoroughly investigate the part in question. The cost of such investigation will be borne by the Government. Any defects will be cause for rejection; replace and retest rejected parts at the Contractor's expense.

2.3.2 Tests of Machinery and Structural Units

The details for tests of machinery and structural units shall conform to the requirements of the particular sections of these specifications covering these items. Assemble each complete machinery and structural unit and test them in the shop, in the presence of the Contracting Officer, unless otherwise directed. Waiving of tests will not relieve the Contractor of responsibility for any fault in operation, workmanship or material that occurs before the completion of the contract or guarantee. After being installed at the site, each complete machinery or structural unit shall be operated through a sufficient number of complete cycles to demonstrate to the satisfaction of the Contracting Officer that it meets the specified operational requirements in all respects.

2.3.3 Inspection of Structural Steel Welding

Nondestructive examination of designated welds will be required. Supplemental examination of any joint or coupon cut from any location in any joint may be required.

2.3.3.1 Visual Examination

For all visual examination of completed welds clean and carefully examine for insufficient throat or leg sizes, cracks, undercutting, overlap, excessive convexity or reinforcement and other surface defects to ensure compliance with the requirements of AWS D1.1/D1.1M, Section 6, subsection 6.9, Part C.

2.3.3.2 Nondestructive Examination

Perform as designated or described in the sections of these specifications, the nondestructive examination of shop and field welds covering the particular items of work.

a. Testing Agency - The nondestructive examination of welds and the evaluation of examination tests as to the acceptability of the welds shall be performed by a testing agency adequately equipped and competent to perform such services or by the Contractor using suitable equipment and qualified personnel. In either case, written approval of the examination procedures is required and the examination tests shall be made in the presence of the Contracting Officer. The evaluation of examination tests are subject to the approval and all records become the property of the Government.

b. Examination Procedures - Conform to the following requirements.

   (1) Ultrasonic Testing - Making, evaluating and reporting ultrasonic testing of welds shall conform to the requirements of AWS D1.1/D1.1M, Section 6, Part C. Provide ultrasonic equipment capable of making a permanent record of the test indications. Make a record of each weld tested.

   (2) Radiographic Testing - Making, evaluating and reporting radiographic testing of welds shall conform to the requirements of AWS D1.1/D1.1M, Section 6, Parts C and E.

   (3) Magnetic Particle Inspection - Magnetic particle inspection of welds shall conform to the applicable provisions of ASTM E709.

   (4) Dye Penetrant Inspection - Perform dye penetrant inspection of welds conforming to the applicable provisions of ASTM E165.

c. Acceptability of Welds - Welds will be unacceptable if shown to have defects prohibited by AWS D1.1/D1.1M, or possess any degree of incomplete fusion, inadequate penetration or undercutting.

2.3.3.3 Test Coupons

The Government reserves the right to require the Contractor to remove coupons from completed work when doubt as to soundness cannot be resolved by nondestructive examination. Should tests of any two coupons cut from the work of any welder show strengths less than that specified for the base metal it will be considered evidence of negligence or incompetence and such welder will be removed from the work. When coupons are removed from any part of a structure, repair the members cut in a neat manner with joints of the proper type to develop the full strength of the members. Repaired joints shall be peened as approved or directed to relieve residual stress. The expense for removing and testing coupons, repairing cut members and the nondestructive examination of repairs shall be borne by the Government or the Contractor in accordance with the Contract Clauses INSPECTION AND ACCEPTANCE.

2.3.3.4 Supplemental Examination

When the soundness of any weld is suspected of being deficient due to faulty welding or stresses that might occur during shipment or erection, the Government reserves the right to perform nondestructive supplemental examinations before final acceptance. The cost of such inspection will be borne by the Government.

2.3.4 Structural Steel Welding Repairs

Repair defective welds in the structural steel welding repairs in accordance with AWS D1.1/D1.1M, Subsection 3.7. Remove defective weld metal to sound metal by use of air carbon-arc or oxygen gouging. Do not use oxygen gouging on ASTM A514/A514M steel. Thoroughly clean surfaces before welding. Retest welds that have been repaired by the same methods used in the original inspection. Except for the repair of members cut to remove test coupons and found to have acceptable welds costs of repairs and retesting will be borne by the Contractor. Submit welding repair plans for steel prior to making repairs.

2.3.5 Inspection and Testing of Steel Stud Welding

Perform fabrication and verification inspection and testing of steel stud welding conforming to the requirements of AWS D1.1/D1.1M, Subsection 7.8 except as otherwise specified. The Contracting Officer will serve as the verification inspector. One stud in every 100 and studs that do not show a full 360 degree weld flash, have been repaired by welding or whose reduction in length due to welding is less than normal shall be bent or torque tested as required by AWS D1.1/D1.1M, Subsection 7.8. If any of these studs fail, bend or torque test two additional studs. If either of the two additional studs fails, all of the studs represented by the tests will be rejected. Studs that crack under testing in the weld, base metal, or shank will be rejected and replaced by the Contractor at no additional cost.

2.3.6 Inspection of Steel Castings

Perform radiographic inspection of steel castings as designated and as described in the section of these specifications covering the particular item of work. The procedure for making, evaluating and reporting the radiographic inspection shall conform to the requirements of ASTM E94. The castings will be unacceptable if shown to have defects of greater severity than the applicable reference standard as illustrated in ASTM E446. The evaluation of the radiographs will be subject to approval and all records will become the property of the Government.

PART 3 EXECUTION

3.1 INSTALLATION

Thoroughly clean all parts to be installed. Remove packing compounds, rust, dirt, grit and other foreign matter. Clean holes and grooves for lubrication. Examine enclosed chambers or passages to make sure that they are free from damaging materials. Where units or items are shipped as assemblies they will be inspected prior to installation. Disassembly, cleaning and lubrication will not be required except where necessary to place the assembly in a clean and properly lubricated condition. Do not use pipe wrenches, cold chisels or other tools likely to cause damage to the surfaces of rods, nuts or other parts used for assembling and tightening parts. Tighten bolts and screws firmly and uniformly but take care not to overstress the threads. When a half nut is used for locking a full nut place the half nut first followed by the full nut. Lubricate threads of all bolts except high strength bolts, nuts and screws with an approved lubricant before assembly. Coat threads of corrosion-resisting steel bolts and nuts with an approved anti-galling compound. Driving and drifting bolts or keys will not be permitted.

3.1.1 Alignment and Setting

Accurately align each machine or structural unit by the use of steel shims or other approved methods so that no binding in any moving parts or distortion of any member occurs before it is fastened in place. The alignment of all parts with respect to each other shall be true within the respective tolerances required. Set true machines to the elevations shown.

3.1.2 Blocking and Wedges

Remove all blocking and wedges used during installation for the support of parts to be grouted in foundations before final grouting unless otherwise directed. Blocking and wedges left in the foundations with approval shall be of steel or iron.

3.1.3 Foundations and Grouting

Concreting of sub-bases and frames and the final grouting under parts of machines shall be in accordance with the procedures as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2 TESTS

3.2.1 Workmanship

Workmanship must be of the highest grade and in accordance with the best modern practices to conform with the specifications for the item of work being furnished.

3.2.2 Production Welding

Perform production welding conforming to the requirements of AWS D1.1/D1.1M or AWS D1.2/D1.2M, as applicable. Studs, on which pre-production testing is to be performed, shall be welded in the same general position as required on production items (flat, vertical, overhead or sloping). Test and production stud welding will be subjected to visual examination or inspection. If the reduction of the length of studs becomes less than normal as they are welded, stop welding immediately and do not resume until the cause has been corrected.

3.3 PROTECTION OF FINISHED WORK

3.3.1 Machined Surfaces

Thoroughly clean foreign matter off machined surfaces. All finished surfaces shall be protected by suitable means. Oil and wrap unassembled pins and bolts with moisture resistant paper or protect them by other approved means. Wash finished surfaces of ferrous metals to be in bolted contact, with an approved rust inhibitor and coat them with an approved rust resisting compound for temporary protection during fabrication, shipping and storage periods. Paint finished surfaces of metals which will be exposed after installation, except corrosion resisting steel or nonferrous metals.

3.3.2 Lubrication After Assembly

After assembly fill all lubricating systems with the lubricant specified and apply additional lubricant at intervals as required to maintain the equipment in satisfactory condition until acceptance of the work.

3.3.3 Aluminum

Protect aluminum that will be in contact with grout or concrete from galvanic or corrosive action, with a coat of zinc-chromate primer and a coat of aluminum paint. Protect aluminum in contact with structural steel against galvanic or corrosive action with a coat of zinc-chromate primer and a coat of aluminum paint. Provide aluminum paint consisting of an aluminum paste conforming to ASTM D962, spar varnish and thinner compatible with the varnish. Field mix the aluminum paint in proportion of 1 kg (2 pounds) of paste, not more than 4 L (one gallon) of spar varnish and not more than 500 mL (one pint) of thinner.

-- End of Section --

SECTION 05 51 00

METAL STAIRS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 314	(1990; R 2008) Standard Specification for Steel Anchor Bolts

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2010) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.3.8M	(1981; R 2005) Metric Hex Lag Screws
ASME B18.21.1	(2009) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)
ASME B18.22M	(1981; R 2010) Metric Plain Washers
ASME B18.6.1	(1981; R 2008) Wood Screws (Inch Series)
ASME B18.6.3	(2010) Machine Screws, Tapping Screws, and Machine Drive Screws (Inch Series)
ASME B18.6.5M	(2000; R 2010) Standard Specification for Metric Thread-Forming and Thread-Cutting Tapping Screws
ASME B18.6.7M	(1999; R 2010) Metric Machine Screws

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened

ASTM A1011/A1011M	(2014) Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
ASTM A108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A27/A27M	(2010) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A283/A283M	(2003; R 2007) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A29/A29M	(2012) Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought General Requirements for
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A512	(2006) Standard Specification for Cold-Drawn Buttweld Carbon Steel Mechanical Tubing
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A568/A568M	(2011b) Standard Specifications for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A575	(1996; R 2007) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A6/A6M	(2014) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C514	(2004e1; R 2009) Standard Specification for Nails for the Application of Gypsum Board
ASTM C636/C636M	(2008) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM E488	(1996; R 2003) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM F1679	(2004e1) Standard Test Method for Using a Variable Incidence Tribometer
ASTM F568M	(2007) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3507	(2008) Carbon Steel Pipes for Ordinary

Piping

KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 3566	(2009) Carbon Steel Tubes for General Structural Purposes

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MBG 531	(2009) Metal Bar Grating Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Metal Stair System; G

SD-03 Product Data

Structural Steel Tubing; G
Hot-Rolled Carbon Steel Bars
Cold-Rolled Carbon Steel Sheets
Galvanized Carbon Steel Sheets
Cold-Drawn Steel Tubing
Concrete Inserts; G
Masonry Anchorage Devices; G
Steel Stairs; G
Steel Stairs, Circular; G

1.3 QUALIFICATIONS FOR WELDING WORK

Section 05 05 23 WELDING, STRUCTURAL applies to work specified in this section.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

Submit complete and detailed fabrication drawings for all iron and steel hardware, and for all steel shapes, plates, bars and strips used in accordance with the design specifications referenced in this section.

Pre-assemble items in the shop to the greatest extent possible. Disassemble units only to the extent necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

For the fabrication of work exposed to view, use only materials that are smooth and free of surface blemishes, including pitting, seam marks, roller marks, rolled trade names, and roughness. Remove blemishes by grinding, or by welding and grinding, prior to cleaning, treating, and application of surface finishes, including zinc coatings.

2.2 STRUCTURAL STEEL PLATES, SHAPES AND BARS

Structural-size shapes and plates, conforming to ASTM A36/A36M, or KS D 3515 unless otherwise noted, except bent or cold-formed plates.

Steel plates - bent or cold-formed, conforming to ASTM A283/A283M, Grade C.

Steel bars and bar-size shapes, conforming to ASTM A36/A36M, or KS D 3515 unless otherwise noted for steel bars and bar-size shapes.

2.3 STRUCTURAL STEEL TUBING

Structural steel tubing, hot-formed, welded or seamless, shall conform to ASTM A500/A500M, Grade B, or KS D 3566 unless otherwise noted.

2.4 HOT-ROLLED CARBON STEEL BARS

Hot-rolled carbon steel bars and bar-size shapes, conforming to ASTM A575, grade as selected by the fabricator.

2.5 COLD-FINISHED STEEL BARS

Cold-finished steel bars conforming to ASTM A108, grade as selected by the fabricator.

2.6 HOT-ROLLED CARBON STEEL SHEETS AND STRIPS

Hot-rolled carbon sheets and strips conforming to ASTM A568/A568M and ASTM A1011/A1011M, pickled and oiled.

2.7 COLD-ROLLED CARBON STEEL SHEETS

Cold-rolled carbon steel sheets conforming to ASTM A1008/A1008M.

2.8 GALVANIZED CARBON STEEL SHEETS

Galvanized carbon steel sheets conforming to ASTM A653/A653M, with galvanizing conforming to ASTM A653/A653M and ASTM A924/A924M.

2.9 COLD-DRAWN STEEL TUBING

Cold drawn steel tubing conforming to ASTM A512, sunk drawn, butt-welded, cold-finished, and stress-relieved.

2.10 GRAY IRON CASTINGS

Gray iron castings conforming to ASTM A48/A48M, Class 30.

2.11 MALLEABLE IRON CASTINGS

Malleable iron castings conforming to ASTM A47/A47M, grade as selected.

2.12 STEEL PIPE

Steel pipe conforming to ASTM A53/A53M, or KS D 3507 type as selected, Grade B; primed finish, unless galvanizing is required; standard weight

(Schedule 40).

2.13 CONCRETE INSERTS

Threaded-type concrete inserts consisting of galvanized ferrous castings, internally threaded to receive M20 (3/4-inch) diameter machine bolts; either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M, hot-dip galvanized in accordance with ASTM A153/A153M.

Wedge-type concrete inserts consisting of galvanized box-type ferrous castings designed to accept M20 (3/4-inch) diameter bolts having special wedge-shaped heads; either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M and hot-dip galvanized in accordance with ASTM A153/A153M.

Carbon steel bolts having special wedge-shaped heads, nuts, washers, and shims and galvanized in accordance with ASTM A153/A153M. Provide slotted-type concrete inserts consisting of galvanized 3 millimeter (1/8-inch) thick pressed steel plate conforming to ASTM A283/A283M; of box-type welded construction with slot designed to receive M20 (3/4-inch) diameter square-head bolt with knockout cover; and be hot-dip galvanized in accordance with ASTM A123/A123M.

2.14 MASONRY ANCHORAGE DEVICES

Provide masonry anchorage devices consisting of expansion shields complying with AASHTO M 314, ASTM E488 and ASTM C514 as follows:

a. Lead expansion shields for machine screws and bolts 6 millimeter (1/4 inch) and smaller; head-out embedded nut type, single unit class, Group I, Type 1, Class 1.

b. Lead expansion shields for machine screws and bolts larger than 6 millimeter (1/4 inch) in size; head-out embedded nut type, multiple unit class, Group I, Type 1, Class 2.

c. Bolt anchor expansion shields for lag bolts; zinc-alloy, long shield anchors class, Group II, Type 1, Class 1.

d. Bolt anchor expansion shields for bolts; closed-end bottom bearing class, Group II, Type 2, Class 1.

Toggle bolts of the tumble-wing type, conforming to ASTM A325M (ASTM A325), ASTM A449 and ASTM C636/C636M, type, class, and style as required.

2.15 FASTENERS

Galvanized zinc-coated fasteners in accordance with ASTM A153/A153M and used for exterior applications or where built into exterior walls or floor systems. Select fasteners for the type, grade, and class required for the installation of steel stair items.

Standard/regular hexagon-head bolts and nuts be conforming to ASTM F568M, (ASTM A307, Grade A).

Square-head lag bolts conforming to ASME B18.2.3.8M, (ASME B18.2.1).

Machine screws cadmium-plated steel conforming to ASME B18.6.7M, (ASME B18.6.3).

Wood screws, flat-head carbon steel conforming to ASME B18.6.5M, (ASME B18.6.1).

Plain washers, round, general-assembly-grade, carbon steel conforming to ASME B18.22M (ASME B18.21.1).

Lock washer helical spring, carbon steel conforming to (ASME B18.2.1) ASME B18.2.3.8M.

2.16 GENERAL FABRICATION

Prepare and submit metal stair system shop drawings with detailed plans and elevations at not less than 1 to 12 scale (1 inch to 1 foot) with details of sections and connections at not less than 1 to 4 scale (3 inches to 1 foot). Also detail placement drawings, diagrams, templates for installation of anchorage, including but not limited to, concrete inserts, anchor bolts, and miscellaneous metal items having integral anchorage devices.

Use materials of size and thicknesses indicated or, if not indicated, of required size and thickness to produce adequate strength and durability in finished product for intended use. Work materials to dimensions indicated on approved detail drawings, using proven details of fabrication and support. Use type of materials indicated or specified for the various components of work.

Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 0.8 millimeter (1/32 inch), and bend metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

Continuously weld corners and seams in accordance with the recommendations of AWS D1.1/D1.1M. Grind smooth exposed welds and flush to match and blend with adjoining surfaces.

Form exposed connections with hairline joints that are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated or, if not indicated, use Phillips flathead (countersunk) screws or bolts.

Provide and coordinate anchorage of the type indicated with the supporting structure. Fabricate anchoring devices, space as indicated and required to provide adequate support for the intended use of the work.

Use hot-rolled steel bars for work fabricated from bar stock unless work is indicated or specified as fabricated from cold-finished or cold-rolled stock.

2.17 PROTECTIVE COATING

Hot dip galvanize steelwork as indicated in accordance with ASTM A123/A123M. Touch up abraded surfaces and cut ends of galvanized members with zinc-dust, zinc-oxide primer, or an approved galvanizing repair compound.

2.18 STEEL PAN STAIRS

2.18.1 General

Use welding for joining pieces together. Fabricate units so that bolts and other fastenings do not appear on finish surfaces. Make joints true and tight, and connections between parts lightproof tight. Grid smooth continuous welds where exposed.

Construct metal stair units to sizes and arrangements indicated to support a minimum live load of 500 kilogram per square meter (100 pounds per square foot). Provide framing, hangers, columns, struts, clips, brackets, bearing plates, and other components as required for the support of stairs and platforms.

2.18.2 Stair Framing

Fabricate stringers of structural steel channels, or plates, or a combination thereof as indicated. Provide closures for exposed ends of strings.

Construct platforms of structural steel channel headers and miscellaneous framing members as indicated. Bolt headers to stringers and newels and framing members to stringers and headers.

2.18.3 Riser, Sub-tread, And Sub-platform Metal Pans

Form metal pans of 2.8 millimeter (0.1084-inch) thick structural steel sheets, conforming to ASTM A1011/A1011M, Grade 36. Shape pans to configuration indicated.

Form metal pans of 2.8 millimeter (0.1084-inch) thick galvanized structural steel sheets, conforming to ASTM A653/A653M, Grade A, with zinc coating conforming to ASTM A653/A653M and ASTM A924/A924M. Shape of pans to configuration indicated.

Construct riser and sub-tread metal pans with steel angle supporting brackets, of size indicated, welded to stringers. Secure metal pans to brackets with rivets or welds. Secure sub-platform metal pans to platform frames with welds.

2.18.4 Metal Safety Nosings

Cast metal abrasive safety nosings, nonskid type, 100 millimeter (4 inches) wide by full length of step between stringers. Fabricate to thickness, profile, and surface pattern as indicated. Equip each nosing with integral anchors for embedding in pan fill material, and spaced not more than 100 millimeter (4 inches) from each end and not more than 380 millimeter (15 inches)on center.

2.18.5 Steel Floor Plate Treads And Platforms

Provide raised pattern steel floor plate fabricated from steel complying with ASTM A36/A36M. Provide pattern as indicated or, if not indicated, as selected from manufacturer's standard patterns.

Form treads of 6 millimeter (1/4-inch) thick steel floor plate with integral nosing and back edge stiffener. Weld steel supporting brackets to strings and treads to brackets.

Fabricate platforms of steel floor plate to thickness indicated. Provide nosing that match treads at landings. Secure floor plates to platform framing members with welds.

2.18.6 Floor Grating Treads And Platforms

Provide floor grating treads and platforms conforming to ASTM A6/A6M, ASTM A29/A29M and NAAMM MBG 531, "Metal Bar Grating Manual." Provide pattern, spacing, and bar sizes as indicated:

a. Galvanized finish conforming to ASTM A123/A123M.

b. Manufacturer's baked-on primer for painted finishes.

Fabricate grating treads with steel plate nosing on one edge and with steel angle or steel plate carrier at each end for string connections. Secure treads to strings with bolts.

Fabricate grating platforms with nosing that matches on grating treads at landings. Provide toe-plates at open-sided edges of floor grating to platform framing members.

2.18.7 Safety Nosings For Concrete Treads

Provide safety nosings of cast aluminum with plain abrasive-surfaces, or extruded aluminum with abrasive inserts, at least 100 mm (4 inches) wide and 6 mm (1/4 inch) thick and terminating at not more than 150 mm (6 inches) from the ends of treads for stairs and for platforms and landings. Provide safety nosings with anchors embedded a minimum of 20 mm (3/4 inch) in the concrete and with tops flush with the top of the traffic surface.

2.18.8 Steel Stairs

Provide steel stairs complete with stringers, steel-plate treads and risers, landings, columns, handrails, and necessary bolts and other fastenings.

2.18.8.1 Design Loads

Design stairs to sustain a live load of not less than 4.8 kPa (100 pounds per square foot), or a concentrated load of 135 kg (300 lbs) applied where it is most critical. Conform to AISC 360 with the design and fabrication of steel stairs, other than a commercial product. Design fire stairs to conform to NFPA 101.

2.18.8.2 Materials

Provide steel stairs of welded construction except that bolts may be used where welding is not practicable. Screw or screw-type connections are not permitted.

a. Structural Steel: ASTM A36/A36M.

b. Gratings for Treads and Landings: NAAMM MBG 531; ASTM A653/A653M, Z275 (G-90) for steel; ASTM B209M (ASTM B209) for aluminum.

c. Support steel floor plate on angle cleats welded to stringers or treads with integral cleats, welded or bolted to the stringer. Close exposed ends.

e. Before fabrication, obtain necessary field measurements and verify drawing dimensions.

f. Clean metal surfaces free from mill scale, flake rust and rust pitting prior to shop finishing. Weld permanent connections. Finish welds flush and smooth on surfaces that will be exposed after installation.

2.18.9 Steel Stairs, Circular

Provide standard open riser design in steel, minimum of 1800 mm (6 feet) in outside diameter with 12 treads to the circle. Construct center pole from 90 mm (3 1/2 inch) minimum outside diameter circular cold drawn seamless tube, in one continuous length, with cap at top and base plate having countersunk machine screws and expansion shields for fastening to concrete floor slab. Construct treads and platforms from steel grating conforming to NAAMM MBG 531. Provide nonslip nosings for gratings. Design slip resistant gratings to exceed a static coefficient of friction of 0.5 as tested in accordance with ASTM F1679.

2.18.10 Soffit Clips

Provide clips with holes for attaching metal furring for plastered soffits. Space clips not more than 300 millimeter (12 inches) on center and be welded to stair treads and platforms as required.

2.18.11 Steel Framing For Concrete Stairs

Customize fabricated units to the dimensions and details indicated, and modified as required to fit actual dimensions of the supporting structure. Use welded construction for fabrication of steel components. Provide 2 millimeter (14-gage) steel risers Unless otherwise indicated. Arrange components to receive finish materials as indicated.

2.19 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 STEEL STAIRS

Provide anchor bolts, grating fasteners, washers, and all parts or devices necessary for proper installation. Provide lock washers under nuts.

3.2 INSTALLATION OF SAFETY NOSINGS

Completely embed nosing in concrete before the initial set of the concrete occurs and finish flush with the top of the concrete surface.

3.3 FIELD WELDING

Execute procedures of manual shielded metal arc welding, appearance and quality of welds made, and methods used in correcting welding work in compliance with AWS D1.1/D1.1M.

3.4 TOUCHUP PAINTING

Immediately after installation, clean all field welds, bolted connections, and abraded areas of the shop painted material, and repaint exposed areas with the same paint used for shop painting. Apply paint by brush or spray to provide a minimum dry-film thickness of 0.051 millimeter (2 mils).

-- End of Section --

SECTION 05 51 33

METAL LADDERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A924/A924M	(2014) Standard Specification for General

	Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B108/B108M	(2014) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM D1187/D1187M	(1997; R 2011e1) Asphalt-Base Emulsions for Use as Protective Coatings for Metal

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping
KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 3566	(2009) Carbon Steel Tubes for General Structural Purposes

MASTER PAINTERS INSTITUTE (MPI)

MPI 79	(Oct 2009) Alkyd Anti-Corrosive Metal Primer

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27	Fixed Ladders

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office

that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Ladder fabrication and installation drawings

SD-03 Product Data

Ladders

1.3 QUALIFICATION OF WELDERS

Qualify welders in accordance with AWS D1.1/D1.1M. Use procedures, materials, and equipment of the type required for the work.

1.4 Drawings

Submit ladder fabrication and installation drawings showing layout(s), connections to structural system, and anchoring details.

1.5 DELIVERY, STORAGE, AND PROTECTION

Protect from corrosion, deformation, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Structural Carbon Steel

ASTM A36/A36M or KS D 3515.

2.1.2 Structural Tubing

ASTM A500/A500M or KS D 3566.

2.1.3 Steel Pipe

ASTM A53/A53M, Type E or S, Grade B or KS D 3507.

2.1.4 Fittings for Steel Pipe

Standard malleable iron fittings ASTM A47/A47M.

2.1.5 Aluminum Alloy Products

Conform to ASTM B209M (ASTM B209) for sheet plate, ASTM B221M (ASTM B221) for extrusions and ASTM B26/B26M or ASTM B108/B108M for castings, as applicable. Provide aluminum extrusions at least 3 mm (1/8 inch) thick and aluminum plate or sheet at least 1.3 mm (0.050 inch) thick.

2.2 FABRICATION FINISHES

2.2.1 Galvanizing

Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing: ASTM A123/A123M, ASTM A153/A153M, ASTM A653/A653M or ASTM A924/A924M, Z275 (G90), or KS D 3506 as applicable.

2.2.2 Galvanize

Anchor bolts, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

2.2.3 Repair of Zinc-Coated Surfaces

Repair damaged surfaces with galvanizing repair method and paint conforming to ASTM A780/A780M or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Contracting Officer. Clean areas to be repaired and remove slag from welds. Heat surfaces to which stick or paste material is applied with a torch to a temperature sufficient to melt the metallic to stick or paste; spread molten material uniformly over surfaces to be coated and wipe off excess material.

2.2.4 Shop Cleaning and Painting

2.2.4.1 Surface Preparation

Blast clean surfaces in accordance with SSPC SP 6/NACE No.3. Surfaces that will be exposed in spaces above ceiling or in attic spaces, crawl spaces, furred spaces, and chases may be cleaned in accordance with SSPC SP 3 in lieu of being blast cleaned. Wash cleaned surfaces which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean.

2.2.4.2 Pretreatment, Priming and Painting

Apply pretreatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of 0.03 mm (1.0 mil). Tint additional prime coat with a small amount of tinting pigment.

2.2.5 Nonferrous Metal Surfaces

Protect by plating, anodic, or organic coatings.

2.2.6 Aluminum Surfaces

2.2.6.1 Surface Condition

Before finishes are applied, remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.

2.2.6.2 Aluminum Finishes

Unexposed plate and extrusions may have mill finish as fabricated. Sandblast castings' finish, medium, AA DAF45. Unless otherwise specified, provide all other aluminum items with standard mill finish. Provide a coating thickness not less than that specified for protective and decorative type finishes for items used in interior locations or architectural Class I type finish for items used in exterior locations in

AA DAF45.

2.3 LADDERS

Fabricate vertical ladders conforming to Section 7 of 29 CFR 1910.27. Use 65 by 10 mm (2 1/2 by 3/8 inch) steel flats for stringers and 20 mm (3/4 inch) diameter steel rods for rungs. Rungs to be not less than 400 mm (16 inches) wide, spaced one foot apart, plug welded or shouldered and headed into stringers. Install ladders so that the distance from the rungs to the finished wall surface will not be less than 175 mm (7 inches). Provide heavy clip angles riveted or bolted to the stringer and drilled for not less than two 12 mm (1/2 inch) diameter expansion bolts as indicated. Provide intermediate clip angles not over 1200 mm (48 inches) on centers.

2.3.1 Ladder Cages

Conform to 29 CFR 1910.27. Fabricate 50 by 6 mm (2 by 1/4 inch) horizontal bands and 40 by 5 mm (1 1/2 by 3/16 inch) vertical bars. Provide attachments for fastening bands to the side rails of ladders or directly to the structure. Provide and fasten vertical bars on the inside of the horizontal bands. Extend cages not less than 690 mm (27 inches) or more than 710 mm (28 inches) from the centerline of the rungs, excluding the flare at the bottom of the cage, and not less than 690 mm (27 inches) in width. Clear the inside of the cage of projections.

2.4 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Install items at locations indicated, according to manufacturer's instructions. Verify all measurements and take all field measurements necessary before fabrication. Provide Exposed fastenings of compatible materials, generally matching in color and finish, and harmonize with the material to which fastenings are applied. Include materials and parts necessary to complete each item, even though such work is not definitely shown or specified. Poor matching of holes for fasteners will be cause for rejection. Conceal fastenings where practicable. Thickness of metal and details of assembly and supports must provide strength and stiffness. Formed joints exposed to the weather to exclude water. Items listed below require additional procedures.

3.2 WORKMANSHIP

Metalwork must be well formed to shape and size, with sharp lines and angles and true curves. Drilling and punching must produce clean true lines and surfaces. Continuously weld along the entire area of contact. Do not tack weld exposed connections of work in place. Grid smooth exposed welds. Provide smooth finish on exposed surfaces of work in place, unless otherwise approved. Where tight fits are required, mill joints. Cope or miter corner joints, well formed, and in true alignment.

Install in accordance with manufacturer's installation instructions and approved drawings, cuts, and details.

3.3 ANCHORAGE, FASTENINGS, AND CONNECTIONS

Provide anchorage where necessary for fastening metal items securely in place. Include for anchorage not otherwise specified or indicated slotted inserts, expansion anchors, and powder-actuated fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine bolts, carriage bolts and powder-actuated threaded studs for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish, to which fastenings are applied. Conceal fastenings where practicable.

3.4 WELDING

Perform welding, welding inspection, and corrective welding, in accordance with AWS D1.1/D1.1M. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation.

3.5 FINISHES

3.5.1 Dissimilar Materials

Where dissimilar metals are in contact, protect surfaces with a coat conforming to MPI 79 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete, plaster, mortar, masonry, wood, or absorptive materials subject to wetting, protect with ASTM D1187/D1187M, asphalt-base emulsion.

3.5.2 Field Preparation

Remove rust preventive coating just prior to field erection, using a remover approved by the rust preventive manufacturer. Surfaces, when assembled, must be free of rust, grease, dirt and other foreign matter.

3.5.3 Environmental Conditions

Do not clean or paint surface when damp or exposed to foggy or rainy weather, when metallic surface temperature is less than minus 15 degrees C (5 degrees F) above the dew point of the surrounding air, or when surface temperature is below 7 degrees C(45 degrees F) or over 35 degrees C (95 degrees F), unless approved by the Contracting Officer.

3.6 LADDERS

Secure to the adjacent construction with the clip angles attached to the stringer. Secure to masonry or concrete with not less than two 12 mm (1/2 inch) diameter expansion bolts. Install intermediate clip angles not over 1200 mm (48 inches) on center. Install brackets as required for securing of ladders welded or bolted to structural steel or built into the masonry or concrete. Ends of ladders must not rest upon finished roof.

-- End of Section --

SECTION 05 52 00

METAL RAILINGS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 180	(2011) Standard Specification for Corrugated Sheet Steel Beams for Highway Guardrail
AASHTO M 314	(1990; R 2008) Standard Specification for Steel Anchor Bolts

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.3.8M	(1981; R 2005) Metric Hex Lag Screws
ASME B18.21.1	(2009) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)
ASME B18.22M	(1981; R 2010) Metric Plain Washers
ASME B18.6.1	(1981; R 2008) Wood Screws (Inch Series)
ASME B18.6.3	(2010) Machine Screws, Tapping Screws, and Machine Drive Screws (Inch Series)
ASME B18.6.5M	(2000; R 2010) Standard Specification for Metric Thread-Forming and Thread-Cutting Tapping Screws
ASME B18.6.7M	(1999; R 2010) Metric Machine Screws

ASTM INTERNATIONAL (ASTM)

ASTM A108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and

	Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A27/A27M	(2010) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A283/A283M	(2003; R 2007) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A467/A467M	(2007) Standard Specification for Machine Coil Chain
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A512	(2006) Standard Specification for Cold-Drawn Buttweld Carbon Steel Mechanical Tubing
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A575	(1996; R 2007) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings

ASTM B429/B429M	(2010e1) Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM C514	(2004e1; R 2009) Standard Specification for Nails for the Application of Gypsum Board
ASTM C636/C636M	(2008) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM E488	(1996; R 2003) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM F568M	(2007) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping
KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 3566	(2009) Carbon Steel Tubes for General Structural Purposes

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM AMP 521	(2001) Pipe Railing Manual

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication and Installation Drawings

SD-03 Product Data

Steel Railings and Handrails
Aluminum Railings and Handrails

SD-07 Certificates

Welding Procedures; G

Welder Qualification; G

SD-08 Manufacturer's Instructions

Installation Instructions; G

1.3 QUALITY ASSURANCE

1.3.1 Welding Procedures

Section 05 05 23 WELDING, STRUCTURAL applies to work specified in this section.

Submit welding procedures testing in accordance with AWS D1.1/D1.1M made in the presence of the Contracting Officer and by an approved testing laboratory at the Contractor's expense.

1.3.2 Welder Qualification

Submit certified welder qualification by tests in accordance with AWS D1.1/D1.1M, or under an equivalent approved qualification test.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide complete, detailed fabrication and installation drawings for all iron and steel hardware, and for all steel shapes, plates, bars and strips used in accordance with the design specifications referenced in this section.

Pre-assemble items in the shop to the greatest extent possible. Disassemble units only to the extent necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

For the fabrication of work exposed to view, use only materials that are smooth and free of surface blemishes, including pitting, seam marks, roller marks, rolled trade names, and roughness. Remove blemishes by grinding, or by welding and grinding, prior to cleaning, treating, and application of surface finishes, including zinc coatings.

2.2 GENERAL FABRICATION

Provide railings and handrails detail plans and elevations at not less than 1 to 12 scale (1 inch to 1 foot). Provide details of sections and connections at not less than 1 to 4 scale (3 inches to 1 foot). Also detail setting drawings, diagrams, templates for installation of anchorages, including concrete inserts, anchor bolts, and miscellaneous metal items having integral anchors.

Use materials of size and thicknesses indicated or, if not indicated, of required size and thickness to produce adequate strength and durability in finished product for intended use. Work materials to dimensions indicated on approved detail drawings, using proven details of fabrication and support. Use type of materials indicated or specified for the various components of work.

Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ensure all exposed edges are eased to a radius of approximately 0.8 millimeter (1/32 inch). Bend metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

Weld corners and seams continuously and in accordance with the recommendations in AWS D1.1/D1.1M. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form exposed connections with hairline joints that are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated or, if not indicated, use Phillips flathead (countersunk) screws or bolts.

Provide anchorage of the type indicated and coordinated with the supporting structure. Fabricate anchoring devices and space as indicated and as required to provide adequate support for the intended use of the work.

Use hot-rolled steel bars for work fabricated from bar stock unless work is indicated or specified to be fabricated from cold-finished or cold-rolled stock.

2.3 STRUCTURAL STEEL PLATES, SHAPES AND BARS

Provide structural-size shapes and plates, except plates to be bent or cold-formed, conforming to ASTM A36/A36M or KS D 3515, unless otherwise indicated.

Provide steel plates, to be bent or cold-formed, conforming to ASTM A283/A283M, Grade C, unless otherwise indicated.

Provide steel bars and bar-size shapes conforming to ASTM A36/A36M or KS D 3515, unless otherwise noted.

2.4 STRUCTURAL STEEL TUBING

Provide structural steel tubing, hot-formed, welded or seamless, conforming to ASTM A500/A500M or KS D 3566, Grade B, unless otherwise noted.

2.5 HOT-ROLLED CARBON STEEL BARS

Provide bars and bar-size shapes conforming to ASTM A575, grade as selected by the fabricator.

2.6 COLD-FINISHED STEEL BARS

Provide cold-finished steel bars conforming to ASTM A108, grade as selected by the fabricator.

2.7 COLD-DRAWN STEEL TUBING

Provide tubing conforming to ASTM A512, sunk drawn, butt-welded, cold-finished, and stress-relieved.

2.8 STEEL PIPE

Provide pipe conforming to ASTM A53/A53M or KS D 3507, type as selected, Grade B; primed finish, unless galvanizing is required; standard weight (Schedule 40).

2.9 CONCRETE INSERTS

Provide threaded-type concrete inserts consisting of galvanized ferrous castings, internally threaded to receive M20 (3/4-inch) diameter machine bolts; either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M, hot-dip galvanized in accordance with ASTM A153/A153M, or provide wedge-type concrete inserts consisting of galvanized box-type ferrous castings designed to accept M20 (3/4-inch) diameter bolts having special wedge-shaped heads, made of either malleable iron conforming to ASTM A47/A47M or cast steel conforming to ASTM A27/A27M and hot-dip galvanized in accordance with ASTM A153/A153M, or provide carbon steel bolts having special wedge-shaped heads, nuts, washers, and shims, galvanized in accordance with ASTM A153/A153M. Provide slotted-type concrete inserts consisting of galvanized 3 millimeter (1/8-inch)thick pressed steel plate conforming to ASTM A283/A283M, made of box-type welded construction with slot designed to receive M20 (3/4-inch) diameter square-head bolt with knockout cover; and hot-dip galvanized in accordance with ASTM A123/A123M.

2.10 MASONRY ANCHORAGE DEVICES

Provide masonry anchorage devices consisting of expansion shields complying with AASHTO M 314, ASTM E488 and ASTM C514 as follows:

Provide lead expansion shields for machine screws and bolts 6 millimeter (1/4 inch) and smaller; head-out embedded nut type, single unit class, Group I, Type 1, Class 1, or

Provide lead expansion shields for machine screws and bolts larger than 6 millimeter) (1/4 inch)in size; head-out embedded nut type, multiple unit class, Group I, Type 1, Class 2, or

Provide bolt anchor expansion shields for lag bolts; zinc-alloy, long shield anchors class, Group II, Type 1, Class 1, or

Provide bolt anchor expansion shields for bolts; closed-end bottom bearing class, Group II, Type 2, Class 1.

Provide tumble-wing type toggle bolts conforming to ASTM A325M (ASTM A325), ASTM A449 and ASTM C636/C636M, type, class, and style as required.

2.11 FASTENERS

Provide galvanized zinc-coated fasteners in accordance with ASTM A153/A153M used for exterior applications or where built into exterior walls or floor systems. Select fasteners for the type, grade, and class required for the installation of steel stair items as indicated on contract drawings or as indicated.

Provide standard hexagon-head bolts, conforming to ASTM F568M (ASTM A307, Grade A).

Provide square-head lag bolts conforming to ASME B18.2.3.8M (ASME B18.2.1).

Provide cadmium-plated steel machine screws conforming to ASME B18.6.7M (ASME B18.6.3).

Provide flat-head carbon steel wood screws conforming to ASME B18.6.5M (ASME B18.6.1).

Provide plain round, general-assembly-grade, carbon steel washers conforming to ASME B18.22M (ASME B18.21.1).

Provide helical spring, carbon steel lock washers conforming to ASME B18.2.3.8M (ASME B18.2.1).

2.12 PROTECTIVE COATING

Shop prime steelwork with red oxide primer in accordance with SSPC Paint 25.

Provide hot dipped galvanized steelwork as indicated in accordance with ASTM A123/A123M. Touch up abraded surfaces and cut ends of galvanized members with zinc-dust, zinc-oxide primer, or an approved galvanizing repair compound.

2.13 STEEL RAILINGS AND HANDRAILS

Design handrails to resist a concentrated load of 490 N (250 lbs) in any direction at any point of the top of the rail or 290 N/m (20 lbs per foot) applied horizontally to top of the rail, whichever is more severe. In accordance with NAAMM AMP 521, provide the same size rail and post. Provide pipe collars of the same material and finish as the handrail and posts. Provide series 300 stainless steel pipe collars.

2.13.1 Steel Handrails

Provide steel handrails, including inserts in concrete, steel pipe conforming to ASTM A53/A53M or KS D 3507, or structural tubing conforming to ASTM A500/A500M or KS D 3566, Grade A or B of equivalent strength. Provide steel railings of 40 or 50 mm (1 1/2 or 2 inches) nominal size, hot-dip galvanized and shop painted.

a. Fabrication: Joint posts, rail, and corners by one of the following methods:

    (1) Flush-type rail fittings of commercial standard, welded and ground smooth with railing splice locks secured with 10 mm (3/8 inch)hexagonal-recessed-head setscrews.

    (2) Mitered and welded joints made by fitting post to top rail and intermediate rail to post, mitering corners, groove welding joints, and grinding smooth. Butt railing splices and reinforce them by a tight fitting interior sleeve not less than 150 mm (6 inches) long.

    (3) Railings may be bent at corners in lieu of jointing, provided bends are made in suitable jigs and the pipe is not crushed.

Provide kick plates between railing posts where indicated, and consist of 4 millimeter (1/8-inch) steel flat bars not less than 150 millimeter (6 inches) high. Secure kick plates as indicated.

Provide galvanized exterior and interior railings where indicated, including pipe, fittings, brackets, fasteners, and other ferrous metal components. Provide black steel pipe for interior railings not indicated as galvanized.

Provide galvanized railings, including pipe, fittings, brackets, fasteners, and other ferrous metal components.

2.14 ALUMINUM RAILINGS AND HANDRAILS

Provide railings and handrails consisting of 40 or 50 mm (1 1/2 or 2 inch) nominal schedule 40 pipe ASTM B429/B429M. Provide anodized aluminum railings, unless otherwise indicated. Ensure all fasteners are Series 300 stainless steel.

a. Fabrication: Provide jointing by one of the following methods:

   (1) Flush-type rail fittings, welded and ground smooth with splice locks secured with 10 mm (3/8 inch) recessed head set screws.

   (2) Ensure all mitered and welded joints made by fitting post to top rail, intermediate rail to post, and corners, are groove welded and ground smooth. Provide butted splices, where allowed by the Contracting Officer, reinforced by a tight fitting dowel or sleeve not less than 150 mm (6 inches) in length. Tack weld or epoxy cement dowel or sleeve to one side of the splice.

   (3) Assemble railings using slip-on aluminum-magnesium alloy fittings for joints. Fasten fittings to pipe or tube with 6 or 10 mm (1/4 or 3/8 inch) stainless steel recessed head setscrews. Provide assembled railings with fittings only at vertical supports or at rail terminations attached to walls. Provide expansion joints at the midpoint of panels. Provide a setscrew in only one side of the slip-on sleeve. Provide alloy fittings to conform to ASTM B26/B26M.

b. Removable railing sections: Provide removable railing sections as indicated. Provide toe-boards and brackets where indicated, using flange castings as appropriate.

2.15 SAFETY CHAINS AND GUARDRAILS

Provide safety chains of galvanized steel, straight link type, 5 mm (3/16 inch) diameter, with at least twelve links per 300 mm (one foot), and with snap hooks on each end. Test safety chain in accordance with ASTM A467/A467M, Class CS. Provide snap hooks of boat type. Provide galvanized 10 mm (3/8 inch) bolt with 20 mm (3/4 inch) eye diameter for attachment of chain, anchored as indicated. Supply two chains, 100 mm (4 inches) longer than the anchorage spacing, for each guarded area. Provide corrugated sheet steel beam guardrail conforming to the requirements of AASHTO M 180, type and class as indicated on contract drawings. Provide bolts and nuts as indicated, conforming to the requirements of ASTM A307. Locate guard rails or safety chain where indicated. Mount the top chain or rail 1050 mm (3 feet 6 inches) above the floor or ground and mount the lower chain or rail 600 mm (2 feet) above the floor or ground.

2.16 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA

EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

Submit manufacturer's installation instructions for the following products to be used in the fabrication of steel stair and hand rail work:

a. Masonry anchorage devices

b. Steel railings and handrails

c. Aluminum railings and handrails

d. Anchorage and fastening systems

Provide complete, detailed fabrication and installation drawings for all iron and steel hardware, and for all steel shapes, plates, bars and strips used in accordance with the design specifications referenced in this section.

3.2 PREPARATION

Adjust stair railings and handrails prior to securing in place to ensure proper matching at butting joints and correct alignment throughout their length. Space posts not more than 2.4 meter (8 feet) on center. Plumb posts in each direction. Secure posts and rail ends to building construction as follows:

Anchor posts in concrete by means of pipe sleeves set and anchored into concrete. Provide sleeves of galvanized, standard weight, steel pipe, not less than 150 millimeter (6 inches) long, and having an inside diameter not less than 13 millimeter (1/2-inch) greater than the outside diameter of the inserted pipe post. Provide steel plate closure secured to the bottom of the sleeve, with closure width and length not less than 25 millimeter (1-inch) greater than the outside diameter of the sleeve. After posts have been inserted into sleeves, fill the annular space between post and sleeve with molten lead, sulfur, or quick-setting hydraulic cement. Cover anchorage joint with a round steel flange welded to the post.

Anchor posts to steel with steel oval flanges, angle type or floor type as required by conditions, welded to posts and bolted to the steel supporting members.

Anchor rail ends into concrete and masonry with steel round flanges welded to rail ends and anchored into the wall construction with lead expansion shields and bolts.

Anchor rail ends to steel with steel oval or round flanges welded to tail ends and bolted to the structural steel members.

Secure handrails to walls by means of wall brackets and wall return fitting at handrail ends. Provide brackets of malleable iron castings, with not less than 75 millimeter (3-inch) projection from the finish wall surface to the center of the pipe drilled to receive one M10 (3/8-inch) bolt. Locate brackets not more than 1525 millimeter (60 inches) on center. Provide wall return fittings of cast iron castings, flush-type, with the same projection as that specified for wall brackets. Secure wall brackets and wall return fittings to building construction as follows:

For concrete and solid masonry anchorage, use bolt anchor expansion shields and lag bolts.

For hollow masonry and stud partition anchorage, use toggle bolts having square heads.

Install toe boards and brackets where indicated. Make splices, where required, at expansion joints. Install removable sections as indicated.

3.3 STEEL HANDRAIL

Install in pipe sleeves embedded in concrete and filled with non-shrink grout or quick setting anchoring cement with anchorage covered with standard pipe collar pinned to post, by means of pipe sleeves secured to wood with screws, with expansion shields and bolts or toggle bolts if installed in masonry, or by means of base plates bolted to stringers or structural steel frame work, as required. Secure rail ends by steel pipe flanges anchored by expansion shields and bolts.

3.4 ALUMINUM HANDRAIL

Affix to base structure by flanges anchored to concrete or other existing masonry by expansion shields, by base plates or flanges bolted to stringers or structural steel framework, by flanges through-bolted to a backing plate on other side of a wall, or by flanges lag bolted to studs or other structural timbers, as required. Provide Series 300 stainless steel bolts to anchor aluminum alloy flanges, of a size appropriate to the standard product of the manufacturer. Where aluminum or alloy fittings or extrusions are to be in contact with dissimilar metals or concrete, coat the contact surface a heavy coating of bituminous paint.

3.5 FIELD WELDING

Ensure procedures of manual shielded metal arc welding, appearance and quality of welds made, and methods used in correcting welding work comply with AWS D1.1/D1.1M.

3.6 TOUCHUP PAINTING

Immediately after installation, clean field welds, bolted connections, abraded areas of the shop paint, and exposed areas painted with the paint used for shop painting. Apply paint by brush or spray to provide a minimum dry-film thickness of 0.051 millimeter (2 mils).

-- End of Section --

SECTION 06 10 00

ROUGH CARPENTRY

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN FOREST AND PAPER ASSOCIATION (AF&PA)

AF&PA T10	(2001) Wood Frame Construction Manual for One- and Two-Family Dwellings
AF&PA T101	(2005) National Design Specification (NDS) for Wood Construction

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995; R 2004) Basic Hardboard

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION (AITC)

AITC 111	(2005) Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage and Erection
AITC TCM	(2004; Errata 2010) Timber Construction Manual, 5th Edition
ANSI/AITC A190.1	(2007) American National Standard, Structural Glued Laminated Timber

AMERICAN LUMBER STANDARDS COMMITTEE (ALSC)

ALSC PS 20	(2010) American Softwood Lumber Standard

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2010) Manual for Railway Engineering

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA M2	(2007) Standard for Inspection of Treated Wood Products
AWPA M6	(2007) Brands Used on Forest Products

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E30	(2011) Engineered Wood Construction Guide
APA E445	(2002) Performance Standards and

	Qualification Policy for Structural-Use Panels (APA PRP-108)
APA EWS R540	(2007) Builder Tips Proper Storage and Handling of Glulam Beams
APA EWS T300	(2007) Technical Note: Glulam Connection Details
APA F405	(1999) Performance Rated Panels
APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood
APA S350	(2011) Performance Standard for Wood-Based Structural-Use Panels

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts
ASME B18.6.1	(1981; R 2008) Wood Screws (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C1136	(2012) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1396/C1396M	(2011) Standard Specification for Gypsum Board
ASTM C208	(2008a) Cellulosic Fiber Insulating Board
ASTM D1435	(2005) Standard Practice for Outdoor

	Weathering of Plastics
ASTM D198	(2009) Standard Test Methods of Static Tests of Lumber in Structural Sizes
ASTM D2344/D2344M	(2000; R 2006) Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
ASTM D2898	(2010) Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
ASTM D3498	(2011) Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems
ASTM D6007	(2002; R 2008) Standard Test Method for Determining Formaldehyde Concentration in Air from Wood Products Using a Small Scale Chamber
ASTM D6108	(2009) Standard Test Method for Compressive Properties of Plastic Lumber and Shapes
ASTM D6109	(2010) Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastic Lumber and Related Products
ASTM D6111	(2009) Standard Test Method for Bulk Density and Specific Gravity of Plastic Lumber and Shapes by Displacement
ASTM D6112	(2010) Compressive and Flexural Creep and Creep-Rupture of Plastic Lumber and Shapes
ASTM D6117	(2010) Standard Test Methods for Mechanical Fasteners in Plastic Lumber and Shapes
ASTM D696	(2008) Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 degrees C and 30 degrees C With a Vitreous Silica Dilatometer
ASTM E1333	(2010) Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials
ASTM F1667	(2011) Driven Fasteners: Nails, Spikes, and Staples
ASTM F547	(2006) Nails for Use with Wood and Wood-Base Materials

COMPOSITE PANEL ASSOCIATION (CPA)

CPA A208.1	(2009) Medium Density Fiberboard (MDF) For Interior Applications

FM GLOBAL (FM)

FM 4435	(2004) Roof Perimeter Flashing

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2012) International Building Code

NATIONAL HARDWOOD LUMBER ASSOCIATION (NHLA)

NHLA Rules	(2007) Rules for the Measurement & Inspection of Hardwood & Cypress

NORTHEASTERN LUMBER MANUFACTURERS ASSOCIATION (NELMA)

NELMA Grading Rules	(2006) Standard Grading Rules for Northeastern Lumber

REDWOOD INSPECTION SERVICE (RIS) OF THE CALIFORNIA REDWOOD ASSOCIATION (CRA)

RIS Grade Use	(1998) Redwood Lumber Grades and Uses

SOUTHERN CYPRESS MANUFACTURERS ASSOCIATION (SCMA)

SCMA Spec	(1986; Supple. No. 1, Aug 1993) Standard Specifications for Grades of Southern Cypress

SOUTHERN PINE INSPECTION BUREAU (SPIB)

SPIB 1003	(2002) Standard Grading Rules for Southern Pine Lumber

TRUSS PLATE INSTITUTE (TPI)

TPI 1	(2002) National Design Standard for Metal Plate Connected Wood Truss Construction; Commentary and Appendices
TPI HIB	(1991) Commentary and Recommendations for Handling, Installing and Bracing Metal Plate Connected Wood Trusses

U.S. DEPARTMENT OF COMMERCE (DOC)

DOC/NIST PS58	(1973) Basic Hardboard (ANSI A135.4)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1923	(Rev A; Notice 2) Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt Anchors)

CID A-A-1924	(Rev A; Notice 2) Shield, Expansion (Self Drilling Tubular Expansion Shell Bolt Anchors
CID A-A-1925	(Rev A; Notice 2) Shield Expansion (Nail Anchors)
FS UU-B-790	(Rev A; Am 1; Notice 1) Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

WEST COAST LUMBER INSPECTION BUREAU (WCLIB)

WCLIB 17	(2000) Standard Grading Rules

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA G-5	(2011) Western Lumber Grading Rules

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1002	(2001) Hexagon Head Bolts and Hexagon Head Screws
KS D 3553	(2001) Round Wire Nails
KS F 3021	(2005) Structural Glued Laminated Timber
KS F 3101	(2006) Ordinary Plywood
KS F 3104	(2006) Particle Boards
KS F 3113	(2004) Plywood for Structure
KS F 3200	(2006) Fiberboards

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabricated structural members; G
Modifications of structural members; G

Drawings of structural laminated members, fabricated wood trusses, engineered wood joists and rafters, and other fabricated structural members indicating materials, shop fabrication, and field erection details; including methods of fastening.

SD-03 Product Data

Underlayment
Plastic Lumber
Fiberboard Wall Sheathing

Cellulose Honeycomb Panels
Fire-retardant treatment
Engineered wood products
Structural-use and OSB panels
Oriented Strand Board
Adhesives

SD-05 Design Data

Modifications of structural members; G

SD-06 Test Reports

Preservative-treated lumber and plywood

SD-07 Certificates

Certificates of grade

Manufacturer's certificates (approved by an American Lumber Standards approved agency) attesting that lumber and material not normally grade marked meet the specified requirements. Certificate of Inspection for grade marked material by an American Lumber Standards Committee (ALSC) recognized inspection agency prior to shipment.

Preservative treatment

1.3 DELIVERY AND STORAGE

Deliver materials to the site in an undamaged condition. Store, protect, handle, and install prefabricated structural elements in accordance with manufacturer's instructions and as specified. Store materials off the ground to provide proper ventilation, with drainage to avoid standing water, and protection against ground moisture and dampness. Store materials with a moisture barrier at both the ground level and as a cover forming a well ventilated enclosure. Store wood I-beams and glue-laminated beams and joists on edge. Adhere to requirements for stacking, lifting, bracing, cutting, notching, and special fastening requirements. Laminated timber shall be handled and stored in accordance with AITC 111 or APA EWS R540. Remove defective and damaged materials and provide new materials. Store separated reusable wood waste convenient to cutting station and area of work.

1.4 GRADING AND MARKING

1.4.1 Lumber

Mark each piece of framing and board lumber or each bundle of small pieces of lumber with the grade mark of a recognized association or independent inspection agency. Such association or agency shall be certified by the Board of Review, American Lumber Standards Committee, to grade the species used. Surfaces that are to be exposed to view shall not bear grade marks, stamps, or any type of identifying mark. Hammer marking will be permitted on timbers when all surfaces will be exposed to view.

1.4.2 Structural Glued Laminated Timber

Mark each member with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of structural glued laminated timber products. The marking shall indicate compliance with ANSI/AITC A190.1 or KS F 3021 and shall include all identification information required by ANSI/AITC A190.1 or KS F 3021. Structurally end-jointed lumber shall also be certified and grade marked in accordance with ANSI/AITC A190.1.

1.4.3 Plywood

Mark each sheet with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of the plywood. The mark shall identify the plywood by species group or span rating, exposure durability classification, grade, and compliance with APA L870 or KS F 3101. Surfaces that are to be exposed to view shall not bear grade marks or other types of identifying marks.

1.4.4 Structural-Use and OSB Panels

Mark each panel with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of the panel. The mark shall indicate end use, span rating, and exposure durability classification. Oriented Strand Board (OSB), APA F405.

1.4.5 Preservative-Treated Lumber and Plywood

The Contractor shall be responsible for the quality of treated wood products. Each treated piece shall be inspected in accordance with AWPA M2 and permanently marked or branded, by the producer, in accordance with AWPA M6. The Contractor shall provide Contracting Officer's Representative (COR) with the inspection report of an approved independent inspection agency that offered products comply with applicable AWPA Standards. The appropriate Quality Mark on each piece will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.4.6 Fire-Retardant Treated Lumber

Mark each piece in accordance with AWPA M6, except pieces that are to be natural or transparent finished. In addition, exterior fire-retardant lumber shall be distinguished by a permanent penetrating blue stain. Labels of a nationally recognized independent testing agency will be accepted as evidence of conformance to the fire-retardant requirements of AWPA M6.

1.4.7 Hardboard, Gypsum Board, and Fiberboard

Mark each sheet or bundle to identify the standard under which the material is produced and the producer.

1.5 SIZES AND SURFACING

ALSC PS 20 for dressed sizes of yard and structural lumber. Lumber shall be surfaced four sides. Size references, unless otherwise specified, are nominal sizes, and actual sizes shall be within manufacturing tolerances allowed by the standard under which the product is produced. Other measurements are IP or SI standard.

1.6 MOISTURE CONTENT

Air-dry or kiln-dry lumber. Kiln-dry treated lumber after treatment. Maximum moisture content of wood products shall be as follows at the time of delivery to the job site:

a. Framing lumber and board, 19 percent maximum

b. Timbers 125 mm (5 inches) and thicker, 25 percent maximum

c. Roof planking, 15 percent maximum

d. Materials other than lumber; moisture content shall be in accordance with standard under which the product is produced

1.7 PRESERVATIVE TREATMENT

Treat

a. 4 kg per cubic meter (0.25 pcf) intended for above ground use.

b. 6.4 kg per cubic meter (0.40 pcf) intended for ground contact and fresh water use. 9.6 kg per cubic meter (0.60 pcf) intended for Ammoniacal Copper Quaternary Compound (ACQ)-treated foundations. 12.8 to 16.1 kg per cubic meter (0.80 to 1.00 pcf) intended for ACQ-treated pilings. All wood shall be air or kiln dried after treatment. Specific treatments shall be verified by the report of an approved independent inspection agency, or the AWPA Quality Mark on each piece. Do not incise surfaces of lumber that will be exposed. Brush coat areas that are cut or drilled after treatment with either the same preservative used in the treatment or with a 2 percent copper naphthenate solution. All lumber and woodwork shall be preservative treated. Plastic lumber shall not be preservative treated. The following items shall be preservative treated:

   1. Wood framing, woodwork, and plywood up to and including the subflooring at the first-floor level of structures having crawl spaces when the bottoms of such items are 600 mm (24 inches) or less from the earth underneath.

   2. Wood members that are in contact with water.

   3. Exterior wood steps, platforms, and railings; and all wood framing of open, roofed structures.

   4. Wood sills, soles, plates, furring, and sleepers that are less than 600 mm (24 inches) from the ground, furring and nailers that are set into or in contact with concrete or masonry.

   5. Nailers, edge strips, crickets, curbs, and cants for roof decks.

1.8 FIRE-RETARDANT TREATMENT

Fire-retardant treated wood shall be pressure treated Treatment and performance inspection shall be by an independent and qualified testing agency that establishes performance ratings. Each piece or bundle of treated material shall bear identification of the testing agency to indicate performance in accordance with such rating. Treated materials to be exposed to rain wetting shall be subjected to an accelerated weathering technique in accordance with ASTM D2898 prior to being tested. Such items which will not be inside a building, and such items which will be exposed to heat or high humidity, shall receive exterior fire-retardant treatment. Fire-retardant-treated wood products shall be free of halogens, sulfates, ammonium phosphate, and formaldehyde. Items to be treated shall be indicated on contract drawings.

1.9 QUALITY ASSURANCE

1.9.1 Shop Drawing Requirements

For fabricated structural members, trusses, glu-lam members, indicate materials, details of construction, methods of fastening, and erection details. Include reference to design criteria used and manufacturers design calculations. Submit drawings for all proposed modifications of structural members. Do not proceed with modifications until the submittal has been approved.

1.9.2 Data Required

Submit calculations and drawings for all proposed modifications of structural members. Do not proceed with modifications until the submittal has been approved.

1.9.3 Certificates of Grade

Submit certificates attesting that products meet the grade requirements specified in lieu of grade markings where appearance is important and grade marks will deface material.

1.9.4 Plastic Lumber Performance

Plastic lumber intended for use in exterior applications shall have no fading or discoloration and no change in dimensional stability as tested in accordance with ASTM D1435 for a period of 5 years.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Engineered Wood Products

Products shall contain no added urea-formaldehyde if exposed to interior spaces. Determine formaldehyde concentrations in air from engineered wood products under test conditions of temperature and relative humidity in accordance with ASTM D6007 or ASTM E1333. Products shall not be used if formaldehyde concentration is found to be greater than 0.

2.1.2 Plastic Lumber

2.1.2.1 Shear Parallel to Length

Maximum 1,550 K/m2 1,000 psi) in accordance with ASTM D2344/D2344M.

2.1.2.2 Density

ASTM D6111.

2.1.2.3 Compressive Strength

a. Secant Modulus: Minimum 108,511 K/m2 (70,000 psi) in accordance with ASTM D6108.

b. Stress at 3 percent strain: Minimum 2,325 K/m2 (1,500 psi) in accordance with ASTM D6108.

c. Compression Parallel to Grain: Minimum 4,650 K/m2 (3,000 psi) in accordance with ASTM D6112.

d. Compression Perpendicular to Grain: Minimum 1,550 K/m2 (1,000 psi) in accordance with ASTM D6112.

2.1.2.4 Flexural Strength

Minimum 3,100 K/m2 (2,000 psi) in accordance with ASTM D6109.

2.1.2.5 Tensile Strength

Minimum 1,938 K/m2 (1,250 psi) in accordance with ASTM D198.

2.1.2.6 Coefficient of Thermal Expansion

Maximum 0.000044 mm/mm/degree C (0.000080 in/in/degree F) in accordance with ASTM D696.

2.1.2.7 Screw Withdrawal

0.35 K (350 lbs) in accordance with ASTM D6117.

2.1.2.8 Nail Withdrawal

0.15 K (150 lbs) in accordance with ASTM D6117.

2.2 LUMBER

2.2.1 Structural Lumber

Any of the species and grades listed in AF&PA T101 that have allowable unit stresses indicated. Use for joists, rafters, headers, trusses, beams (except collar beams), columns, posts, stair stringers, girders, and all other members indicated to be stress rated. Design of members and fastenings shall conform to AITC TCM. Other stress graded or dimensioned items such as blocking, carriages, and studs shall be standard or No. 2 grade except that studs may be Stud grade.

2.2.2 Framing Lumber

Framing lumber such as studs, plates, caps, collar beams, cant strips, bucks, sleepers, nailing strips, and nailers and board lumber such as subflooring and wall and roof sheathing shall be one of the species listed in the table below. Minimum grade of species shall be as listed.

Table of Grades for Framing and Board Lumber			
Grading Rules	Species	Framing	Board Lumber
WWPA G-5 standard grading rules	Aspen, Douglas Fir-Larch, Douglas Fir South, Engelmann Spruce-Lodgepole Pine, Engelmann Spruce, Hem-Fir, Idaho White Pine, Lodgepole Pine, Mountain Hemlock, Mountain Hemlock-Hem-Fir, Ponderosa Pine-Sugar Pine, Ponderosa Pine-Lodgepole Pine, Subalpine Fir, White Woods, Western Woods, Western Cedars, Western Hemlock	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m (10 feet) and shorter)	All Species: No. 3 Common
WCLIB 17 standard grading rules	Douglas Fir-Larch, Hem-Fir, Mountain Hemlock, Sitka Spruce, Western Cedars, Western Hemlock	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m (10 feet) and shorter)	All Species: Standard

Table of Grades for Framing and Board Lumber

Grading Rules	Species	Framing	Board Lumber
SPIB 1003 standard grading rules	Southern Pine	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m (10 feet) and shorter)	No. 2 Boards
SCMA Spec standard specifications	Cypress	No. 2 Common	No. 2 Common
NELMA Grading Rules standard grading rules	Balsam Fir, Eastern Hemlock-Tamarack, Eastern Spruce, Eastern White Pine, Northern Pine, Northern Pine-Cedar	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m (10 feet) and shorter)	All Species: No. 3 Common except Standard for Eastern White and Northern Pine
RIS Grade Use standard specifications	Redwood	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m (10 feet) and shorter)	Construction Heart

Table of Grades for Framing and Board Lumber			
Grading Rules	Species	Framing	Board Lumber
NHLA Rules rules for the measurement and inspection of hardwood and cypress lumber	Cypress	No. 2 Dimension	No. 2 Common

2.2.3 Structural Glued Laminated Timber

ANSI/AITC A190.1, allowable working stress values for loads of normal duration.

Fabricated with wet-use adhesives. Beams shall use glue-laminated and FSC-certified lumber. Posts and studs shall use laminated-strand lumber. Joists shall use laminated-veneer lumber. Members shall be Premium Appearance Grade, sealed with a penetrating sealer, and individually wrapped as standard with the manufacturer and approved. Members shall be complete with hardware for joining laminated members and for their connection to other construction.

2.3 PLYWOOD, STRUCTURAL-USE, AND ORIENTED STRAND BOARD (OSB) PANELS

APA L870 or KS F 3101, APA S350 or KS F 3113, APA E445, and APA F405 respectively.

2.3.1 Subflooring

2.3.1.1 Plywood

C-D Grade, Exposure 1 durability classification, Span rating of 24/16 or greater.

2.3.1.2 Structural-Use and OSB Panels

Sheathing grade with durability equivalent to Exposure 1, Span Rating of 32/16 or greater. OSB, APA E445, Rated Sturd-I-Floor.

2.3.2 Combination Subfloor-Underlayment

2.3.2.1 Plywood

Underlayment Grade, Exposure 1, or Exterior Type, C-C (Plugged) Grade. Minimum thickness shall be as listed below except where indicated to have greater thickness.

Support Spacing	Underlayment Minimum Thickness
400 mm (16 inches)	12.7 mm (1/2 inch) for Group 1 species
	15 mm (19/32 inch) for Group 2 and 3 species
	18 mm (23/32 inch) for Group 4 species
600 mm (24 inches)	18 mm (23/32 inch) for Group 1 species
	22 mm (7/8 inch) for Group 2 and 3 species
	25 mm (1 inch) for Group 4 species

2.3.2.2 Structural-Use Panel

Combination subfloor-underlayment grade with durability equivalent to Interior plywood with Exterior glue (Exposure 1), Span Rating of 16 or greater, unless otherwise indicated on contract drawings.

2.3.3 Wall Sheathing

2.3.3.1 Plywood

C-D Grade, Exposure 1, and a minimum thickness of 12.7 mm (1/2 inch) except where indicated to have greater thickness.

2.3.3.2 Structural-Use and OSB Panels

Sheathing grade with durability equivalent to Exposure 1, Span Rating of 16/0 or greater. OSB, APA Rated Sheathing. OSB shall be a phenolic-glued, low-formaldehyde board.

2.3.4 Roof Sheathing

2.3.4.1 Plywood

C-D Grade, Exposure 1, with an Identification Index of not less than 24/0. Provide exterior grade particleboard with phenol resin for interior and exterior applications.

2.3.4.2 Structural-Use Panel

Sheathing grade with durability equivalent to Exposure 1, Span Rating of 24/0 or greater.

2.4 UNDERLAYMENT

Underlayment shall conform to one of the following:

2.4.1 Hardboard

AHA A135.4 service class, sanded one side, 6 mm (1/4 inch) thick, 1200 mm (4 feet) wide.

2.4.2 Particleboard

CPA A208.1, Grade 1-M-1, or KS F 3104, 6 mm (1/4 inch) thick, 1200 by 1200 mm (4 by 4 feet). Compressed fibers with resin binder.

2.4.3 Plywood

Plywood shall conform to APA L870 or KS F 3101, underlayment grade with exterior glue, or C-C (Plugged) exterior grade 9 mm (11/32 inch) thick, 1200 mm (4 feet) wide.

2.4.4 Oriented Strand Board

OSB underlayment grade 6 mm (0.225 inch).

2.5 OTHER MATERIALS

2.5.1 Hardboard Underlayment

DOC/NIST PS58, service class, sanded on one side, 6 mm (1/4 inch) thick 1200 mm (4 feet) wide.

2.5.2 Fiberboard Wall Sheathing

ASTM C208 or KS F 3200, 600 mm (2 feet) wide by 13 mm (1/2 inch thick) for supports 400 mm (16 inches) (o.c.) or 1200 mm (4 feet) wide by 20 mm (3/4 inch) thick for supports 600 mm (24 inches) o.c., except only 1200 mm (4 feet) wide by 13 mm (1/2 inch) thick sheathing over supports at 400 mm (16 inches) o.c. may be applied without corner bracing of framing. Sheathing shall be asphalt impregnated or asphalt coated to render the sheathing water resistant but vapor permeable. Structural fiberboard shall contain a minimum of 80 percent recycled content. Non-structural fiberboard shall contain 100 percent post-consumer recycled content.

2.5.3 Gypsum Wall Sheathing

ASTM C1396/C1396M, 12.7 mm (1/2 inch) thick, fire retardant (Type X) 16 mm (5/8 inch) thick, where indicated; 1200 mm (4 feet) wide with square edge for supports 400 mm (16 inches) o.c. with or without corner bracing of framing or for supports 600 mm (24 inches) o.c. with corner bracing of framing; 600 mm (2 feet) wide with V-tongue and groove (T&G) edge for supports 400 or 600 mm (16 or 24 inches) o.c. with corner bracing of framing.

2.5.4 Foil-Faced Insulative Sheathing

Wood fiber core, chemically treated for water resistance, with aluminum foil laminated under pressure to both sides with water-resistant adhesive; 1200 mm (48 inches or 48 3/4 inches) wide; 2 mm (0.078 inch) thick when used with corner bracing, 2.9 mm (0.115 inch) thick with studs up to 400 mm (16 inches) o.c. without corner bracing, or 3.5 mm (0.137 inch) thick with studs up to 600 mm (24 inches) o.c. without corner bracing. The sheathing and installation shall have been accepted by ICC as conforming to ICC IBC. The sheathing alone shall have a thermal resistance value (R value) of not less than 0.20.

2.5.5 Cellulose Honeycomb Panels

ASTM C208. Panels shall be made of kraft paper and shall be impregnated with phenolic resins for moisture resistance. Panels shall contain 100 percent post-consumer recycled content.

2.5.6 Building Paper

FS UU-B-790, Type I, Grade D, Style 1.

2.5.7 Trussed Rafters

Metal plate connected trusses designed in accordance with TPI 1 and TPI HIB and fabricated in accordance with TPI 1.

2.5.8 Trussed Joists

Metal plate connected parallel chord wood trusses designed and fabricated in accordance with TPI 1.

2.5.9 Roof Decking

Roof decking shall be commercial grade with minimum design value of 7.6 MPa (1100 psi) in bending. Decking shall be 100 mm (4 inches) thick with double tongue and groove, unless otherwise indicated; V-jointed, matched and dressed. As an option, fabricated laminated lumber decking with interlocking tongue and groove joints may be provided.

2.5.10 Miscellaneous Wood Members

2.5.10.1 Nonstress Graded Members

Members shall include bridging, corner bracing, furring, grounds, and nailing strips. Members shall be in accordance with TABLE I for the species used. Sizes shall be as follows unless otherwise shown:

Member	Size mm (inch)
Bridging	25 x 75 (1 x 3) or 25 x 100 (1 x 4) for use between members 50 x 300 (2 x 12) and smaller; 50 x 100 (2 x 4) for use between members larger than 50 x 300 (2 x 12).
Corner bracing	25 x 100 (1 x 4).
Furring	25 x 50 (1 x 2)
Nailing strips	25 x 75 (1 x 3) or 25 x 100 (1 x 4) when used as shingle base or interior finish, otherwise 50 mm (2 inch) stock.

2.5.10.2 Wood Bumpers

AREMA Eng Man, Industrial grade cross ties

2.5.10.3 Sill Plates

Sill plates shall be standard or number 2 grade.

2.5.10.4 Blocking

Blocking shall be standard or number 2 grade.

2.5.10.5 Rough Bucks and Frames

Rough bucks and frames shall be straight standard or number 2 grade.

2.5.11 Adhesives

Comply with applicable regulations regarding toxic and hazardous materials and as specified.

2.6 ROUGH HARDWARE

Unless otherwise indicated or specified, rough hardware shall be of the type and size necessary for the project requirements. Sizes, types, and spacing of fastenings of manufactured building materials shall be as recommended by the product manufacturer unless otherwise indicated or specified. Rough hardware exposed to the weather or embedded in or in contact with preservative treated wood, exterior masonry, or concrete walls or slabs shall be hot-dip zinc-coated in accordance with ASTM A153/A153M. Nails and fastenings for fire-retardant treated lumber and woodwork exposed to the weather shall be copper alloy or hot-dipped galvanized fasteners as recommended by the treated wood manufacturer.

2.6.1 Bolts, Nuts, Studs, and Rivets

ASME B18.2.1, ASME B18.5.2.1M, ASME B18.5.2.2M and ASME B18.2.2.

2.6.2 Anchor Bolts

ASTM A307 or KS B 1002, size as indicated, complete with nuts and washers.

2.6.3 Expansion Shields

CID A-A-1923, CID A-A-1924, and CID A-A-1925. Except as shown otherwise, maximum size of devices shall be 10 mm (3/8 inch).

2.6.4 Lag Screws and Lag Bolts

ASME B18.2.1.

2.6.5 Wood Screws

ASME B18.6.1.

2.6.6 Nails and Staples

ASTM F547 or KS D 3553, size and type best suited for purpose; staples shall be as recommended by the manufacturer of the materials to be joined. For sheathing and subflooring, length of nails shall be sufficient to extend 25 mm (1 inch) into supports. In general, 8-penny or larger nails shall be used for nailing through 25 mm (1 inch) thick lumber and for toe nailing 50 mm (2 inch) thick lumber; 16-penny or larger nails shall be used for nailing through 50 mm (2 inch) thick lumber. Nails used with treated lumber and sheathing shall be hot-dipped galvanized in accordance with ASTM A153/A153M. Nailing shall be in accordance with the recommended nailing schedule contained in AF&PA T10. Where detailed nailing requirements are not specified, nail size and spacing shall be sufficient to develop an adequate strength for the connection. The connection's strength shall be verified against the nail capacity tables in AF&PA T101. Reasonable judgment backed by experience shall ensure that the designed connection will not cause the wood to split. If a load situation exceeds a reasonable limit for nails, a specialized connector shall be used.

2.6.7 Wire Nails

ASTM F1667.

2.6.8 Timber Connectors

Unless otherwise specified, timber connectors shall be in accordance with TPI 1, APA EWS T300 or AITC TCM.

2.6.9 Clip Angles

Steel, 5 mm (3/16 inch) thick, size as indicated; or zinc-coated steel or iron commercial clips designed for connecting wood members.

2.6.10 Joist Hangers

Steel or iron, zinc coated, sized to fit the supported member, of sufficient strength to develop the full strength of the supported member in accordance with ICC IBC, and furnished complete with any special nails required.

2.6.11 Tie Straps

For joists supported by the lower flange of steel beams, provide 3 by 40 mm (1/8 by 1-1/2 inch) steel strap, 600 mm (2 feet) long, except as indicated otherwise.

2.6.12 Joist Anchors

For joists supported by masonry walls, provide anchors 5 by 40 mm (3/16 by 1 1/2 inch) steel tee or strap, bent and of length to provide 100 mm (4 inches) embedment into wall and 300 mm (12 inches) along joist except as indicated otherwise. For joists parallel to masonry or concrete walls, provide anchors 6 by 30 mm (1/4 by 1-1/4 inch) minimum cross-sectional area, steel strap, length as necessary to extend over top of first three joists and into wall 100 mm (4 inches), and with wall end of bend or pin type, except as indicated otherwise.

2.6.13 Door Buck Anchors

Metal anchors, 3 by 30 mm (1/8 by 1-1/4 inch) steel, 300 mm (12 inches) long, with ends bent 50 mm (2 inches) , except as indicated otherwise. Anchors shall be screwed to the backs of bucks and built into masonry or concrete. Locate 200 mm (8 inches) above sills and below heads and not more than 600 mm (24 inches) intermediately between. Anchorage of bucks to steel framing shall be as indicated .

2.6.14 Metal Bridging

No. 16 U.S. Standard gage, cadmium-plated or zinc-coated, unless otherwise indicated.

2.6.15 Toothed Rings and Shear Plates

AF&PA T101.

2.6.16 Beam Anchors

Steel U-shaped strap anchors 6 mm (1/4 inch) thick by 40 mm (1-1/2 inches) wide.

2.6.17 Metal Framing Anchors

Construct anchors to the configuration shown using hot dip zinc-coated steel conforming to ASTM A653/A653M, Z275 (G90), unless otherwise indicated. Steel shall be not lighter than 18 gage. Special nails supplied by the manufacturer shall be used for all nailing.

2.6.18 Panel Edge Clips

Extruded aluminum or galvanized steel, H-shaped clips to prevent differential deflection of roof sheathing.

2.7 AIR INFILTRATION BARRIER

Air infiltration barrier shall be building paper meeting the requirements of ASTM C1136, Type IV, style optional or a tear and puncture resistant olefin building wrap (polyethylene or polypropylene) with a moisture vapor transmission rate of 125 g per square meter per 24 hours (125 g per square yard per 24 hours) in accordance with ASTM E96/E96M, Desiccant Method at 23 degrees C or with a moisture vapor transmission rate of 670 g per square meter per 24 hours (670 g per square yard per 24 hours) in accordance with ASTM E96/E96M, Water Method at 23 degrees C.

2.8 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to AF&PA T10 unless otherwise indicated or specified. Select lumber sizes to minimize waste. Fit framing lumber and other rough carpentry, set accurately to the required lines and levels, and secure in place in a rigid manner. Do not splice framing members between bearing points. Set joists, rafters, and purlins with their crown edge up. Frame members for the passage of pipes, conduits, and ducts. Do not cut or bore structural members for the passage of ducts or pipes without approval. Reinforce all members damaged by such cutting or boring by means of specially formed and approved sheet metal or bar steel shapes, or remove and provide new, as approved. Provide as necessary for the proper completion of the work all framing members not indicated or specified. Spiking and nailing not indicated or specified otherwise shall be in accordance with the Nailing Schedule contained in ICC IBC; perform bolting in an approved manner. Spikes, nails, and bolts shall be drawn up tight. Timber connections and fastenings shall conform to AF&PA T101. Provide 50 mm (2 inch) minimum clearance between chimneys and wood framing; provide 100 mm (4 inch) minimum clearance at fireplaces. Fill the spaces with strips of approved noncombustible material. Use slate or steel shims when leveling joists, beams, and girders on masonry or concrete. Do not use shimming on wood or metal bearings. When joists, beams, and girders are placed on masonry or concrete, a wood base plate shall be positioned and leveled with grout. The joist, beam, or girder shall then be placed on the plate. When joists, beams, and girders are set into masonry or concrete, a pocket shall be formed into the wall. The joist, beam, or girder shall then be placed into the pocket and leveled with a steel shim.

3.1.1 Sills

Set sills level and square and wedge with steel or slate shims; point or grout with non-shrinking cement mortar to provide continuous and solid bearing. Anchor sills to the foundations as indicated. Where sizes and spacing of anchor bolts are not indicated, provide not less than 16 mm (5/8 inch) diameter bolts at all corners and splices and space at a maximum of 1800 mm (6 feet) o.c. between corner bolts. Provide at least two bolts for each sill member. Lap and splice sills at corners and bolt through the laps or butt the ends and through-bolt not more than 150 mm (6 inches) from the ends. Provide bolts with plate washers and nuts. Bolts in exterior walls shall be zinc-coated.

3.1.1.1 Anchors in Masonry

Embed anchor bolts not less than 400 mm (15 inches) in masonry unit walls and provide each with a nut and a 50 mm (2 inch) diameter washer at bottom end, unless otherwise indicated. Fully grout bolts with mortar.

3.1.1.2 Anchors in Concrete

Embed anchor bolts not less than 200 mm (8 inches) in poured concrete walls and provide each with a nut and a 50 mm (2 inch) diameter washer at bottom end, unless otherwise indicated. A bent end may be substituted for the nut and washer; bend shall be not less than 90 degrees. Powder-actuated fasteners spaced 900 mm (3 feet) o.c. may be provided in lieu of bolts for single thickness plates on concrete.

3.1.2 Beams and Girders

Set beams and girders level and in alignment and anchor to bearing walls, piers, or supports with U-shaped steel strap anchors. Embed anchors in concrete or masonry at each bearing and through-bolt to the beams or girders with not less than two bolts. Provide bolts not less than 12 mm (1/2 inch) in diameter and with plate washers under heads and nuts. Install beams and girders with 200 mm (8 inch) minimum end bearing on walls or supports, unless otherwise indicated. Install beams and girders into walls with 12 mm (1/2 inch) clearance at the top, end, and sides or standard steel wall-bearing boxes. Provide joints and splices over bearings only and bolt or spike together.

3.1.3 Roof Framing or Rafters

Tops of supports or rafters shall form a true plane. Valley, ridge, and hip members shall be of depth equal to cut on rafters where practicable, but in no case less than depth of rafters and nominally 50 mm (2 inches) thick. Rafters shall have full and solid bearing on plates. Valleys, hips, and ridges shall be straight and true intersections of roof planes. Necessary crickets and watersheds shall be formed. Rafters, except hip and valley rafters, shall be bolted by angles. Rafters shall be toe-nailed to ridge, valley, or hip members with at least three 8-penny nails. Rafters shall be braced to prevent movement until permanent bracing, decking or sheathing is installed. Hip and valley rafters shall be secured to wall plates by clip angles. Openings in roof shall be framed with headers and trimmers. Unless otherwise indicated, headers carrying more than two rafters and trimmers supporting headers carrying more than one rafter shall be double. Hip rafters longer than the available lumber shall be butt jointed and scabbed. Valley rafters longer than the available lumber shall be double, with pieces lapped not less than 1200 mm (4 feet) and well spiked together. Trussed rafters shall be installed in accordance with TPI HIB. Engineered wood joists shall be installed in accordance with distributor's instructions.

3.1.4 Joists

Provide joists of the sizes and spacing indicated, accurately and in alignment, and of uniform width. Joists shall have full bearing on sills, plates, beams, girders, and trusses; provide laps over bearing only and spike. Where joists are of insufficient length to produce a 300 mm (12 inch) lap, butt joists over bearing and provide wood scabs 2 nominal inches thick by depth of joists by 600 mm (24 inches) long or metal straps 6 by 40 mm (1/4 by 1 1/2 inch) by not less than 450 mm (18 inches) long nailed to each joist with not less than four 10-penny nails, or approved sheet metal connectors installed in accordance with the manufacturer's recommendations. Provide joists built into masonry with a beveled fire cut so that the top of the joist does not enter the wall more than 25 mm (one inch) or standard steel wall bearing boxes. Provide metal hangers for joists framing into the side of headers, beams, or girders. When a portion of the joist extends above the top flange of a steel beam or girder, provide a 10 mm (3/8 inch) space between the top flange and the extended portion of the joists to allow for shrinkage of joists. The minimum joist end bearing shall be 100 mm (4 inches), and joists built into concrete or masonry shall have a 12 mm (1/2 inch) minimum clearance at the top, end, and sides. For joists approved to be bored for the passage of pipes or conduits, bore through the neutral axis of the joist. Provide steel joist hangers of proper size and type to receive the ends of all framed joists.

3.1.4.1 Floor (Ceiling) Framing

Except where otherwise indicated joists shall have bearings not less than 100 mm (4 inches) on concrete or masonry and 40 mm (1-1/2 inches) on wood or metal. Joists, trimmers, headers, and beams framing into carrying members at the same relative levels shall be carried on joist hangers. Joists shall be lapped and spiked together at bearings or butted end-to-end with scab ties at joint and spiked to plates. Openings in floors shall be framed with headers and trimmers. Headers carrying more than two tail joists and trimmers supporting headers carrying more than one tail joist shall be doubled, unless otherwise indicated. Joists built into masonry shall be provided with a beveled fire cut so that the top of the joist does not enter the wall more than 25 mm (1 inch) or standard steel wall bearing boxes. Engineered wood joists shall be installed in accordance with distributor's instructions.

3.1.4.2 Doubled Joists

Provide under bearing walls and partitions running parallel with the floor joists, around stairways, chimneys, fireplaces, and at other openings where joists are cut and framed. Double, space for clearance, block apart 1200 mm (4 feet) on center, rigidly frame, and spike together joists under partitions that are to receive ducts, pipes, and conduits.

3.1.4.3 Tie Straps

For joists supported by the lower flange of steel beams, provide straps at every fourth joist and the corresponding fourth joist on the opposite side. Tie joists across the top of the steel beam with a steel strap. Form straps to lie flat across the top of the beam and twist at the ends to provide flat contact with the side of each joist. Nail each strap at each end with three 10-penny nails spaced 50 mm (2 inches) o.c.

3.1.4.4 Joist Anchors

Provide anchors for each fourth joist supported by a masonry wall. Build wall end of anchors into the wall. Nail anchor to the joist with three 10-penny nails spaced 50 mm (2 inches) o.c. Anchor the first three joists parallel to concrete or masonry walls at bridging points, but not less than 2400 mm (8 feet) o.c. from end walls. Let anchors into the tops of each joist and spike to the top of joist with one 10-penny nail. Extend anchors at least 100 mm (4 inches) into the wall.

3.1.5 Bridging

Provide bridging for floor and ceiling joists and for roof rafters having slopes of less than 1/3. Locate bridging as indicated and as specified herein. Provide bridging for spans greater than 1800 mm (6 feet), but do not exceed 2400 mm (8 feet) maximum spacing between rows of bridging. Install rows of bridging uniformly. Provide metal or wood cross-bridging, except where solid bridging is indicated. Do not nail the bottom end of cross-bridging until the subfloor has been laid.

3.1.5.1 Wood Cross-Bridging

Provide wood cross-bridging not less than 1 by 3 nominal size. Nail wood cross-bridging at each end with two 8-penny nails for one by thick material and three 8-penny nails for 2 by thick material.

3.1.5.2 Metal Cross-Bridging

Shall be the manufacturer's standard product, not less than 16 gage before forming and coating. Metal bridging shall be the compression type, lodged into or nailed to the wide faces of opposite joists at points diagonally across from each other near the bottoms and tops of joists.

3.1.6 Subflooring

3.1.6.1 Plywood, Structural-Use, and OSB Panels

Apply best side up with the grain of outer plies or the long dimension at right angles to joists. Stagger end joints and locate over the centerline of joists. Allow 3 mm (1/8 inch) spacing at panel ends and 6 mm (1/4 inch) at panel edges. Panels shall be continuous over two or more spans. Nail panels 150 mm (6 inches) o.c. at supported edges and 250 mm (10 inches) o.c. over intermediate bearing. Nails shall be 8-penny common or 6-penny threaded. Provide at least 12 mm (1/2 inch) clearance between subflooring and masonry or concrete walls. Subflooring may be installed with adhesive conforming to ASTM D3498 and nails spaced at 300 mm (12 inches) on center unless otherwise shown.

3.1.6.2 Combination Subfloor-Underlayment

Apply with the grain of the face plies or the long dimension at right angles to joists. Panels shall be continuous over two or more spans. Stagger end joints of adjacent panels. Panel edges shall be T&G or supported by 2 by 4 members framed between joists so the edge joints of subfloor-underlayment occur over the centerline of blocking. Provide end joints of panels over the centerline of joists. Allow 3 mm (1/8 inch) spacing between panel edge and end joints. Nail panels 150 mm (6 inches) o.c. at ends and edges and 250 mm (10 inches) o.c. along intermediate bearings unless they are glue-nailed in accordance with APA E30. Nails shall be 8-penny coated common or 6-penny threaded. Provide at least 12 mm (1/2 inch) clearance between subfloor-underlayment and masonry or concrete walls.

3.1.6.3 Wood

Subflooring shall be applied diagonally with end joints made over supports. Each board shall bear on at least three supports and shall be nailed at each support using two nails for boards 150 mm (6 inches) and less in width and three nails for boards more than 150 mm (6 inches) in width.

3.1.6.4 Depressed Subfloors

Provide depressed subfloors to receive ceramic and quarry tile floors. Nail cleats or ledgers of one by four material to the sides of joists to support the flooring material. Place the cleats at a depth below the top of the joists sufficient to allow the installation of the subflooring below the tops of joists. Snugly fit subflooring as specified herein between joists.

3.1.7 Underlayment

Install underlayment over subfloor just prior to laying of resilient flooring and protect from water and physical damage. Underlayment shall be hardboard, particleboard, plywood, or OSB. Stagger end joints of underlayment with respect to each other, and stagger all joints with respect to paralleling panel joints in subfloor. Space panels 2 mm (1/16 inch) apart at ends and 3 mm (1/8 inch) apart at edges and at least 12 mm (1/2 inch) from concrete or masonry walls. Nail panels 150 mm (6 inches) o.c. along edges and 150 mm (6 inches) o.c. each way throughout panel, but not closer than 10 mm (3/8 inch) to panel edges. Nails shall be 4-penny annular ring or screw type and shall be countersunk 2 mm (1/16 inch).

3.1.8 Columns and Posts

Set columns and posts, plumb, in alignment, and with full and uniform bearing. Do not embed the bottom and bearing surfaces of posts or columns in concrete or set in direct contact with concrete slabs on grade.Provide post and beam construction with wood bolsters or steel post caps in such a manner that the post above will tier directly over the one below; fabricate the assembly in a rigid and substantial manner using bolts or lag screws.

3.1.9 Wall Framing

3.1.9.1 Studs

Select studs for straightness and set plumb, true, and in alignment. In walls and partitions more than 2400 mm (8 feet) tall, provide horizontal bridging at not more than 2400 mm (8 feet) o.c. using nominal 50 mm (2 inch) material of the same width as the studs; install the bridging flat. Sizes and spacing of studs shall be as indicated. Double studs at jambs and heads of openings and triple at corners to form corner posts. Frame corner posts to receive sheathing, lath, and interior finish. Truss over openings exceeding 1200 mm (4 feet) in width or use a header of sufficient depth. Toe-nail studs to sills or sole plates with four 8-penny nails or fasten with metal nailing clips or connectors. Anchor studs abutting concrete or masonry walls thereto near the top and bottom and at mid-height of each story using expansion bolts or powder-actuated drive studs.

3.1.9.2 Plates

Use plates for walls and partitions of the same width as the studs to form continuous horizontal ties. Splice single plates; stagger the ends of double plates. Double top plates in walls and bearing partitions, built up of two nominal 50 mm (2 inch) thick members. Top plates for nonbearing partitions shall be single or double plates of the same size as the studs. Nail lower members of double top plates and single top plates to each stud and corner post with two 16-penny nails. Nail the upper members of double plates to the lower members with 10-penny nails, two near each end, and stagger 400 mm (16 inches) o.c. intermediately between. Nail sole plates on wood construction through the subfloor to each joist and header; stagger nails. Anchor sole plates on concrete with expansion bolts, one near each end and at not more than 1800 mm (6 feet) o.c., or with powder-actuated fasteners, one near each end and at not more than 900 mm (3 feet) o.c. Provide plates cut for the passage of pipes or ducts with a steel angle as a tie for the plate and bearing for joist.

3.1.9.3 Firestops

Provide firestops for wood framed walls and partitions and for furred spaces of concrete or masonry walls at each floor level and at the ceiling line in the top story. Where firestops are not automatically provided by the framing system used, they shall be formed of closely fitted wood blocks of nominal 50 mm (2 inch) thick material of the same width as the studs and joists. Lightweight concrete units may be used at the first-floor level to serve jointly as firestopping and ratproofing.

3.1.9.4 Diagonal Bracing

Provide diagonal bracing at all external corners and internal angles and at maximum 12000 mm (40 foot) centers in stud walls, except that bracing may be omitted where diagonally applied wood sheathing, plywood or structural-use panel sheathing, 1200 by 2400 mm (4 by 8 foot) fiberboard sheathing, or gypsum board sheathing is used. Bracing shall be of 1 by 6 material, let into the exterior face of studs. Extend bracing from top plates to sill at an angle of approximately 45 degrees and double nail at each stud. When openings occur near corners, provide diagonal knee braces extending from the corner post above headers to top plates and from below window sills to the main sill. Nail bracing at each bearing with two 8-penny nails.

3.1.10 Wall Sheathing

3.1.10.1 Plywood, Structural-Use, and OSB Panel Wall Sheathing

Apply horizontally or vertically. Extend sheathing over and nail to sill and top plate. Abut sheathing edges over centerlines of supports. Allow 3 mm (1/8 inch) spacing between panels and 3 mm (1/8 inch) at windows and doors. If sheathing is applied horizontally, stagger vertical end joints. Nail panels with 6-penny nails spaced 150 mm (6 inches) o.c. along edges of the panel and 300 mm (12 inches) o.c. over intermediate supports. Keep nails 10 mm (3/8 inches) away from panel ledges. Provide 2 by 4 blocking for horizontal edges not otherwise supported.

3.1.10.2 Fiberboard Wall Sheathing

Apply fiberboard wall sheathing allowing a 3 mm (1/8 inch) joint at edges to permit expansion, except at frames and openings where sheathing shall be fitted snugly. Pre-expand sheathing before application, allowing sheathing to condition for humidity as recommended by the sheathing manufacturer. Provide 2 by 4 blocking for horizontal edges not otherwise supported.

a. Fiberboard wall sheathing used with diagonal-braced framing shall be either 60 or 1200 mm (2 or 4 feet) wide. Sheathing 600 mm (2 feet) wide shall have T&G or shiplapped edges and shall be applied horizontally with vertical joints staggered. Apply sheathing with tongued edge up and nail at edges and intermediate bearings with 45 mm (1-3/4 inch) long, zinc-coated steel roofing nails spaced on maximum 115 mm (4-1/2 inch) centers. Apply sheathing 1200 mm (4 feet) wide either horizontally or vertically. Nail sheathing with 45 mm (1-3/4 inch) long, zinc-coated steel roofing nails spaced 100 mm (4 inches) maximum o.c. at edges and 200 mm (8 inches) maximum o.c. at intermediate bearings.

b. Fiberboard wall sheathing used with unbraced framing shall be 1200 mm (4 feet) wide. Apply sheathing vertically. Extend sheathing over and nail to sill and top plates. Locate joints over centerlines of supports. Nail sheathing with 40 mm (1-1/2 inch) long, zinc-coated steel roofing nails with 9.5 mm (3/8 inch) diameter heads. Space nails 75 mm (3 inches) o.c. at edges and ends and 150 mm (6 inches) o.c. at intermediate bearings.

3.1.10.3 Gypsum Sheathing Board

Apply gypsum sheathing board either horizontally or vertically. Butt joints and locate over the centerlines of supports. Horizontally applied sheathing shall be T&G, applied with tongued edge up. Stagger vertical joints and abut sheet closely to frames of openings. Nail sheathing with 11 gage, 9.5 mm (3/8 inch) head, zinc-coated nails 40 mm (1-1/2 inches) long for 12.7 mm (1/2 inch) sheathing and 45 mm (1-3/4 inches) long for 16 mm (5/8 inch) sheathing, spaced 10 mm (3/8 inch) minimum from edges. Provide 2 by 4 blocking for horizontal edges of 1200 mm (4 foot) wide panels not otherwise supported.

a. Gypsum Sheathing Board Used with Diagonal-Braced Framing: Sheathing shall be either 600 or 1200 mm (2 or 4 feet) wide. Apply sheathing 600 mm (2 feet) wide horizontally. Nail 100 mm (4 inches) maximum o.c. at edges and over intermediate bearings. Apply sheathing 1200 mm (4 feet) wide either horizontally or vertically. Nail 150 mm (4 inches) maximum o.c. at edges and 200 mm (8 inches) maximum o.c. at intermediate bearings.

b. Gypsum Sheathing Board Used with Unbraced Frames: Sheathing shall be 1200 mm (4 feet) wide and applied vertically. Extend sheathing over and nail to both sill and top plates. Nail 100 mm (4 inches) maximum o.c. at edges and 200 mm (8 inches) maximum o.c. at intermediate bearings.

3.1.10.4 Foil-Faced Insulative Sheathing

Apply sheathing vertically. Butt or overlap joints and locate over centerline of supports. Attach sheathing to framing with 30 mm (1-1/4 inch), large, flat-head, 11 gage, galvanized roofing nails or 16 gage, 11 mm (7/16 inch) minimum crown, galvanized staples with 30 mm (1-1/4 inch0 legs. For nonstructural application (with corner bracing), space fasteners 150 mm (6 inches) o.c. on all panel edges and 300 mm (12 inches) o.c. on intermediate supports, regardless of sheathing thickness, for studs not more than 600 mm (24 inches) o.c. For structural application (without corner bracing), for studs not more than 400 mm (16 inches) o.c., space fasteners 75 mm (3 inches) o.c. on all edges and 150 mm (6 inches) o.c. on intermediate members using minimum 2.9 mm (0.115 inch0 thickness; for studs up to 600 mm (24 inches) o.c., space fasteners 75 mm (3 inches) o.c. on all edges and 75 mm (3 inches) o.c. on intermediate supports using minimum 3.5 mm (0.137 inch) thickness.

3.1.10.5 Particleboard

Install according to manufacturer's instructions and accepted industry standards.

3.1.10.6 Cellulose Honeycomb Panels

Install according to manufacturer's instructions and accepted industry standards.

3.1.11 Wood Sheathing

Sheathing end joints shall be made over framing members and so alternated that there will be at least two boards between joints on the same support. Each board shall bear on at least three supports. Boards shall be nailed at each support using two nails for boards 150 mm (6 inches) and less in width and three nails for boards more than 150 mm (6 inches) in width. Roof sheathing shall not be installed where roof decking is installed.

3.1.12 Building Paper

Provide building paper on wood board sheathing for all types of exterior siding, unless otherwise indicated. Apply paper shingle fashion, horizontally, beginning at the bottom of the wall. Lap edges 100 mm (4 inches), and nail with 25 mm (one inch), zinc-coated roofing nails, spaced

300 mm (12 inches) o.c. and driven through tin discs.

3.1.13 Ceiling Joists

Size as indicated and set accurately and in alignment. Toe-nail joists to all plates with not less than three 10-penny nails. Frame openings in ceilings with headers and trimmers.

3.1.14 Metal Framing Anchors

Provide framing anchors at every rafter or trussed rafter to fasten rafter or trussed rafter to plates and studs against uplift movement and forces as indicated. Anchors shall be punched and formed for nailing so that nails will be stressed in shear only. Nails shall be zinc-coated; drive a nail in each nail hole provided in the anchor.

3.1.15 Trusses

Metal plate connected wood trusses shall be handled, erected, and braced in accordance with TPI HIB and as indicated.

3.1.16 Structural Glued Laminated Timber Members

Brace members before erection. Align members and complete all connections before removal of bracing. Unwrap individually wrapped members only after adequate protection by a roof or other cover has been provided. Treat scratches and abrasions of factory applied sealer with two brush coats of the same sealer used at the factory.

3.1.17 Plywood and Structural-Use Panel Roof Sheathing

Install with the grain of the outer plies or long dimension at right angles to supports. Stagger end joints and locate over the centerlines of supports. Allow 3 mm (1/8 inch) spacing at panel ends and 6 mm (1/4 inch) at panel edges. Nail panels with 8-penny common nails or 6-penny annular rings or screw-type nails spaced 150 mm (6 inches) o.c. at supported edges and 300 mm (12 inches) o.c. at intermediate bearings. Do not use staples in roof sheathing. Where the support spacing exceeds the maximum span for an unsupported edge, provide adequate blocking, tongue-and-groove edges, or panel edge clips, in accordance with APA E30.

3.1.18 Stair Framing

Cut carriages to exact shape required to receive treads and risers, with risers of uniform height and treads of uniform width. Provide trimmers, nailers, and blocking as required to support finish materials.

3.2 MISCELLANEOUS

3.2.1 Wood Roof Nailers, Edge Strips, Crickets, Curbs, and Cants

Provide sizes and configurations indicated or specified and anchored securely to continuous construction.

3.2.1.1 Roof Nailing Strips

Provide roof nailing strips for roof decks as indicated. Apply nailing strips in straight parallel rows in the direction and spacing indicated. Strips shall be surface applied.

a. Surface-Applied Nailers: Shall be 75 mm (3 inches) wide and of thickness to finish flush with the top of the insulation. Anchor strips securely to the roof deck with powder actuated fastening devices or expansion shields and bolts, spaced not more than 600 mm (24 inches) o.c.

b. Embedded Nailers: Shall be nominal 50 by 75 with 20 mm (2 by 3 with 2 inch) sides beveled. Set and anchor nailers to finish flush with the roof deck surface.

3.2.1.2 Roof Edge Strips and Nailers

Provide at perimeter of roof, around openings through roof, and where roofs abut walls, curbs, and other vertical surfaces. Except where indicated otherwise, nailers shall be 150 mm (6 inches) wide and the same thickness as the insulation. Anchor nailers securely to underlying construction. Anchor perimeter nailers in accordance with FM 4435. Strips shall be grooved for edge venting; install at walls, curbs, and other vertical surfaces with a 6 to 12 mm (1/4 to 1/2 inch) air space.

3.2.1.3 Crickets, Cants, and Curbs

Provide wood saddles or crickets, cant strips, curbs for scuttles and ventilators, and wood nailers bolted to tops of concrete or masonry curbs and at expansion joints, as indicated, specified, or necessary.

3.2.2 Rough Wood Bucks

50 mm (2 inch) nominal thickness. Set wood bucks true and plumb. Anchor bucks to concrete or masonry with steel straps extending into the wall 200 mm (8 inches) minimum. Place anchors near the top and bottom of the buck and space uniformly at 600 mm (2 foot) maximum intervals.

3.2.3 Wood Blocking

Provide proper sizes and shapes at proper locations for the installation and attachment of wood and other finish materials, fixtures, equipment, and items indicated or specified.

3.2.4 Wood Grounds

Provide for fastening wood trim, finish materials, and other items to plastered walls and ceilings. Install grounds in proper alignment and true with an 2400 mm (8 foot) straightedge.

3.2.5 Wood Furring

Provide where shown and as necessary for facing materials specified. Except as shown otherwise, furring strips shall be nominal one by 3, continuous, and spaced 400 mm (16 inches) o.c. Erect furring vertically or horizontally as necessary. Nail furring strips to masonry. Do not use wood plugs. Provide furring strips around openings, behind bases, and at angles and corners. Furring shall be plumb, rigid, and level and shall be shimmed as necessary to provide a true, even plane with surfaces suitable to receive the finish required. Form furring for cornices, offsets and breaks in walls or ceilings on 1 by 4 wood strips spaced 400 mm (16 inches) o.c.

3.2.6 Wood Bumpers

Dress to the sizes indicated, and bevel edges. Bore, countersink, and bolt bumpers in place.

3.2.7 Temporary Closures

Provide with hinged doors and padlocks and install during construction at exterior doorways and other ground level openings that are not otherwise closed. Cover windows and other unprotected openings with polyethylene or other approved material, stretched on wood frames. Provide dust proof barrier partitions to isolate areas as directed.

3.2.8 Temporary Centering, Bracing, and Shoring

Provide for the support and protection of masonry work during construction as required. Forms and centering for cast-in-place concrete work are specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.9 Wood Sleepers

Run wood sleepers in lengths as long as practicable and stagger end joints in adjacent rows.

3.2.10 Diaphragms

Install plywood, structural-use, or OSB panels with the long dimension parallel or perpendicular to supports. End joints shall be staggered and located over the centerline of supports.

3.2.11 Shear Walls

Install plywood or structural-use panels with long dimension parallel or perpendicular to supports. Provide blocking behind edges not located over supports.

3.2.12 Bridging

Wood bridging shall have ends accurately bevel-cut to afford firm contact and shall be nailed at each end with two nails. Metal bridging shall be installed as recommended by the manufacturer. The lower ends of bridging shall be driven up tight and secured after subflooring or roof sheathing has been laid and partition framing installed.

3.2.13 Corner Bracing

Corner bracing shall be installed when required by type of sheathing used or when siding, other than panel siding, is applied directly to studs. Corner bracing shall be let into the exterior surfaces of the studs at an angle of approximately 45 degrees, shall extend completely over wall plates, and shall be secured at each bearing with two nails.

3.2.14 Sill Plates

Sill plates shall be set level and square and anchor bolted at not more than 1800 mm (6 feet) on centers and not more than 300 mm (12 inches) from end of each piece. A minimum of two anchors shall be used for each piece.

3.3 INSTALLATION OF TIMBER CONNECTORS

Installation of timber connectors shall conform to applicable requirements of AF&PA T101.

3.4 ERECTION TOLERANCES

a. Framing members which will be covered by finishes such as wallboard, plaster, or ceramic tile set in a mortar setting bed, shall be within the following limits:

   (1) Layout of walls and partitions: 6 mm (1/4 inch) from intended position;

   (2) Plates and runners: 6 mm in 2400 mm (1/4 inch in 8 feet) from a straight line;

   (3) Studs: 6 mm in 2400 mm (1/4 inch in 8 feet) out of plumb, not cumulative; and

   (4) Face of framing members: 6 mm in 2400 mm (1/4 inch in 8 feet) from a true plane.

b. Framing members which will be covered by ceramic tile set in dry-set mortar, latex-portland cement mortar, or organic adhesive shall be within the following limits:

   (1) Layout of walls and partitions: 6 mm (1/4 inch) from intended position;

   (2) Plates and runners: 3 mm in 2400 mm (1/8 inch in 8 feet) from a straight line;

   (3) Studs: 3 mm in 2400 mm (1/8 inch in 8 feet) out of plumb, not cumulative; and

   (4) Face of framing members: 3 mm in 2400 mm (1/8 in 8 feet) from a true plane.

3.5 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements. Typical conversion is as shown:

PRODUCTS	INCH-POUND Nominal	METRIC Conversion
Sawn lumber	2 by 4	38 by 89 mm
	1 by	19 mm by
Stud spacing	16 inches	400 mm
	If not 48 inches panel	406 mm
Plywood	48 by 96 inches	1200 mm by 2400 mm

-- End of Section --

SECTION 06 20 00

FINISH CARPENTRY

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.6	(1998; R 2006) Hardboard Siding

AMERICAN LUMBER STANDARDS COMMITTEE (ALSC)

ALSC PS 20	(2010) American Softwood Lumber Standard

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C20	(2003) Structural Lumber Fire-Retardant Treatment by Pressure Processes
AWPA C27	(2002) Plywood - Fire-Retardant Treatment by Pressure Processes
AWPA M2	(2007) Standard for Inspection of Treated Wood Products
AWPA M4	(2011) Standard for the Care of Preservative-Treated Wood Products
AWPA P5	(2010) Standard for Waterborne Preservatives

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E445	(2002) Performance Standards and Qualification Policy for Structural-Use Panels (APA PRP-108)
APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood
APA S350	(2011) Performance Standard for Wood-Based Structural-Use Panels

ARCHITECTURAL WOODWORK INSTITUTE (AWI)

AWI AWS	(2009) Architectural Woodwork Standards

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)

ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.6.1	(1981; R 2008) Wood Screws (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM D2898	(2010) Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
ASTM F547	(2006) Nails for Use with Wood and Wood-Base Materials

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.9	(2010) Cabinet Hardware

COMPOSITE PANEL ASSOCIATION (CPA)

CPA A208.1	(2009) Medium Density Fiberboard (MDF) For Interior Applications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA LD 3	(2005) Standard for High-Pressure Decorative Laminates

NATIONAL HARDWOOD LUMBER ASSOCIATION (NHLA)

NHLA Rules	(2007) Rules for the Measurement & Inspection of Hardwood & Cypress

NORTHEASTERN LUMBER MANUFACTURERS ASSOCIATION (NELMA)

NELMA Grading Rules	(2006) Standard Grading Rules for Northeastern Lumber

REDWOOD INSPECTION SERVICE (RIS) OF THE CALIFORNIA REDWOOD ASSOCIATION (CRA)

RIS Grade Use	(1998) Redwood Lumber Grades and Uses

SOUTHERN PINE INSPECTION BUREAU (SPIB)

SPIB 1003	(2002) Standard Grading Rules for Southern Pine Lumber

U.S. DEPARTMENT OF COMMERCE (DOC)

DOC/NIST PS58	(1973) Basic Hardboard (ANSI A135.4)

WEST COAST LUMBER INSPECTION BUREAU (WCLIB)

WCLIB 17	(2000) Standard Grading Rules

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA G-5	(2011) Western Lumber Grading Rules

WINDOW AND DOOR MANUFACTURERS ASSOCIATION (WDMA)

WDMA I.S. 4	(2009) Water-Repellent Preservative Non-Pressure Treatment for Millwork

WOOD MOULDING AND MILLWORK PRODUCERS ASSOCIATION (WMMPA)

WMMPA WM 6	(1987) Industry Standard for Non-Pressure Treating of Wood Millwork

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3553	(2001) Round Wire Nails
KS F 3113	(2004) Plywood for Structure

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Siding
Epoxy-Aggregate Panels
Siding; G

SD-07 Certificates

Certificates of grade
Certificates of compliance

1.3 DETAIL DRAWINGS

The Contractor shall submit detail drawings showing fabricated items and special mill and woodwork items. Drawings shall indicate materials and details of construction, methods of fastening, erection, and installation.

1.4 CERTIFICATES

Provide certificates of grade from the grading agency on graded but unmarked lumber or plywood attesting that materials meet the grade requirements specified herein.

Provide certificates of compliance unless materials bear certification markings or statements.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver lumber, plywood, trim, and millwork to job site in an undamaged condition. Stack materials to ensure ventilation and drainage. Protect against dampness before and after delivery. Store materials under cover in a well-ventilated enclosure and protect against extreme changes in temperature and humidity. Do not store products in building until wet trade materials are dry.

1.6 QUALITY ASSURANCE

1.6.1 Lumber

Identify each piece or each bundle of lumber, millwork, and trim by the grade mark of a recognized association or independent inspection agency that is certified by the Board of Review, American Lumber Standards Committee, to grade the species.

1.6.2 Plywood

Each sheet of plywood shall bear the mark of a recognized association or independent inspection agency that maintains continuing control over quality of the plywood. Mark shall identify plywood by species group or span rating, and shall show exposure durability classification, grade, and compliance with APA L870.

1.6.3 Hardboard and Particleboard

Materials shall bear a marking or statement identifying the producer and the applicable standard.

1.6.4 Pressure-Treated Lumber and Plywood

Each treated piece shall be inspected in accordance with AWPA M2.

1.6.5 Nonpressure-Treated Woodwork and Millwork

Mark, stamp, or label, indicating compliance with WDMA I.S. 4.

1.6.6 Fire-Retardant Treated Lumber

Each piece to bear Underwriters Laboratories label or the label of another nationally recognized independent testing laboratory.

PART 2 PRODUCTS

2.1 WOOD

2.1.1 Sizes and Patterns of Wood Products

Yard and board lumber sizes shall conform to ALSC PS 20. Provide shaped lumber and millwork in the patterns indicated and standard patterns of the association covering the species. Size references, unless otherwise specified, are nominal sizes, and actual sizes shall be within manufacturing tolerances allowed by the applicable standard.

2.1.2 Trim, Finish, and Frames

Provide species and grades listed for materials to be paint finished.

Provide materials that are to be stain, natural, or transparent finished one grade higher than that listed. Provide species indicated for materials to be transparent finished. Run trim, except window stools and aprons with hollow backs.

TABLE OF GRADES FOR WOOD TO RECEIVE PAINT FINISH

Grading Rules	Species	Exterior and Interior Trim, Finish, and Frames
WWPA G-5 standard grading rules	Aspen, Douglas Fir-Larch, Douglas Fir South, Engelmann Spruce-Lodgepole Pine, Engelmann Spruce, Hem-Fir, Idaho White Pine, Lodgepole Pine, Mountain Hemlock, Mountain Hemlock-Hem-Fir, Ponderosa Pine-Sugar Pine, (Ponderosa Pine-Lodgepole Pine,) White Woods, (Western Woods,) Western Cedars, Western Hemlock	All Species: C & Btr. Select (Choice & Btr Idaho White Pine) or Superior Finish. Western Red Cedar may be graded C & Btr. Select or A & Btr. per Special Western Red Cedar Rules.
WCLIB 17 standard grading rules	Douglas Fir-Larch, Hem-Fir, Mountain Hemlock, Sitka Spruce, Western Cedars, Western Hemlock	All Species: C & Btr VG, except A for Western Red Cedar
SPIB 1003 standard grading rules	Southern Pine	C & Btr
NHLA Rules	Cypress	C-Select
NELMA Grading Rule standard grading rules	Balsam Fir, Eastern Hemlock-Tamarack, Eastern Spruce, Eastern White Pine, Northern Pine, Northern Pine, Northern White Cedar	All Species: C-Select except C & BTR for Eastern White Pine and Norway Pine
RIS Grade Use standard specifications	Redwood	Clear, Clear All Heart

TABLE OF GRADES FOR WOOD TO RECEIVE PAINT FINISH		
Grading Rules	Species	Exterior and Interior Trim, Finish, and Frames
NHLA Rules	Cypress	B Finish
	Red Gum	Select or BTR (for interior use only)
	Soft Elm	
	Birch	

2.1.3 Utility Shelving

Utility shelving shall be a suitable species equal to or exceeding requirements of No. 3 Common white fir under WWPA G-5, 25 mm (1 inch) thick; or plywood, interior type, Grade A-B, 13 mm (1/2 inch) thick, any species group.

2.1.4 Softwood Plywood

APA L870, thicknesses as indicated.

a. Plywood for Soffits: Exterior type, B-B medium density overlay.

b. Plywood for Shelving: Interior type, A-B or B-B Grade, any species group.

c. Plywood for Countertops: Exterior type, A-C Grade.

2.1.5 Hardboard

DOC/NIST PS58, standard type, 6 mm (1/4 inch) thick, unless otherwise indicated in contract drawings.

2.1.6 Particleboard

CPA A208.1, Grade 1-M-2 or 2-M-2 or better.

2.1.7 Stairs

Treads 32 mm 1-1/4 inches) thickness, clear red or white oak. Risers 19 mm (1 inch) nominal finish lumber.

2.1.8 Shoe Mold

Clear red or white oak, 13 by 16 mm (1/2 by 5/8 inch) unless otherwise indicated.

2.1.9 Wood Seats

Clear maple, oak, or other suitable hardwood, not less than 40 mm (1-5/8 inches) thick, with rounded edges. Provide stainless steel stanchions or brackets as indicated.

2.1.10 Wood Bumpers

Clear oak, maple or birch, dressed to size indicated and with outer edges beveled.

2.1.11 Catwalks

Boards, 19 by 140 mm (1 by 6 inches nominal), species and grade equal to or exceeding 3 Common Hem-Fir under WWPA G-5.

2.1.12 Siding

Horizontal siding shall be hardboard, plywood, or wood. Panel siding shall be hardboard or plywood.

2.1.12.1 Horizontal Hardboard Siding

AHA A135.6, factory primed face and longitudinal edges, factory sealed back, lap type, 200 mm (8 inches) wide, maximum practicable lengths, 9.5 or 11 mm (3/8 or 7/16 inch) thick, smooth face, unless otherwise indicated in contract drawings.

2.1.12.2 Panel Hardboard Siding

AHA A135.6, factory primed face and longitudinal edges, factory sealed back, 1220 mm (4 feet) wide, maximum practicable lengths, 9.5 or 11 mm (3/8 or 7/16 inch) thick, smooth face, unless otherwise indicated in contract drawings.

2.1.12.3 Horizontal Plywood Siding

APA L870, exterior, medium-density overlay lap type, 150 mm (6 inches) wide, maximum practicable lengths, 13 mm (1/2 inch) thick, smooth face, unless otherwise indicated in contract drawings.

2.1.12.4 Panel Plywood Siding

APA L870, exterior, medium-density overlay, 1220 mm (4 feet) wide, maximum practicable lengths, span rating of 400 mm (16 inches), o.c. smooth face, as selected from manufacturer's standard patterns, unless otherwise indicated in contract drawings.

2.1.12.5 Horizontal Rated Siding

Qualified under APA E445, exterior type medium-density overlay, lap types, 150 mm (6 inches) wide, maximum practicable lengths, 13 mm (1/2 inch) thick, smooth face, unless otherwise indicated in contract drawings.

2.1.12.6 Panel Rated Siding

Qualified under APA E445, exterior type, medium-density overlay 1220 mm (4 feet) wide, maximum practicable lengths, span rated at 400 mm (16 inches)) o.c., smooth face.

2.1.12.7 Wood Siding

Species and grades listed in paragraph entitled "Trim, Finish, and Frames" Table. Siding shall be horizontal bevel type, minimum 5 mm (3/16 inch) thin edge by minimum 11 mm (7/16 inch) thick edge, (1 inch) thick, 200 mm

(8 inches) wide, maximum practicable lengths, smooth face.

2.1.12.8 Wood Structural Panels

Wood Structural Panels shall conform to APA S350 or KS F 3113, exterior, exposure 1, double-faced, 1200 mm (4 feet) wide, maximum practicable lengths, selected from manufacturer's standard patterns to satisfy the wind load for the specified span.

2.1.12.9 Epoxy-Aggregate Panels

Prefinished epoxy-aggregate panels shall consist of an asbestos-free cement board base sheet with a factory applied surface of epoxy resins and decorative natural stone chips. Factory applied finish shall be a minimum of 0.5 mm (20 mils) of 100 percent solids, two-component epoxy resin-based coating followed by an application of inert aggregate. Stone color shall be selected from manufacturer's standard colors. Cement board base sheet shall be a minimum of 6 mm (1/4 inch) thick. Finished panels shall be dimensionally stable. Water absorption on the surfaced side shall not exceed 0.20 percent after 24 hours of submergence in water. Accessories shall be manufacturer's standard extruded matching color aluminum moldings. Moldings shall be provided for meeting strips, end caps, inside corners, or outside corners. Fasteners shall be noncorrosive, self-tapping screw type and finished to match the color of stone. Caulking compound shall be color compatible, low modulus silicone or urethane type. Submoit manufacturer's printed data, showing texture, density, catalog cuts, and installation instructions.

2.2 SOFFITS

2.2.1 Hardboard and Plywood

Hardboard and plywood soffits shall be siding grade hardboard, 10 or 11 mm (3/8 or 7/16 inch) thick; plywood, APA L870, exterior type, plywood panel siding, 9 mm (11/32 inch) thick for 600 mm (24 inch) on centers maximum span with all edges supported.

2.3 FASCIAS AND TRIM

2.3.1 Wood

Fascias and trim, including exterior door and window casing, shall be species and grade listed in TABLE I at the end of this section. Sizes shall be as indicated. Metal corners may be furnished in lieu of wood corner boards for horizontal siding; and if furnished, shall be galvanized steel and primed or aluminum and primed.

2.4 WOOD SHINGLES

Wood shingles shall be No. 1 Grade, Red Cedar, Tidewater Red Cypress or California Redwood in accordance with applicable grading rules under which it is produced, random widths, 400 mm (16 inches) length, unless otherwise indicated, dip-stained at factory in color selected from manufacturer's standard colors. Wood shingles shall be fire-retardant treated as indicated.

2.5 COUNTER TOPS

2.5.1 Laminated Plastic

ANSI/NEMA LD 3.

2.5.1.1 Countertop Finish

Grade GP 50 or PF 42, satin finish. Color and pattern shall be as indicated.

2.5.1.2 Backing Sheet

BK 20.

2.6 MOISTURE CONTENT OF WOOD PRODUCTS

Air-dry or kiln-dry lumber. Kiln-dry treated lumber after treatment. Maximum moisture content of wood products at time of delivery to the job site, and when installed, shall be as follows:

a. Interior Paneling: 6 percent.

b. Interior Finish Lumber, Trim, and Millwork 25 mm (1-1/4 Inches) Nominal or Less in Thickness: 6 percent on 85 percent of the pieces and 8 percent on remainder.

c. Exterior Treated and Untreated Finish Lumber and Trim 89 mm (4 inches Nominal) or Less in Thickness: 19 percent.

d. Exterior Wood Siding: 15 percent.

e. Moisture content of other materials shall be in accordance with the applicable standards.

2.7 PRESERVATIVE TREATMENT OF WOOD PRODUCTS

2.7.1 Nonpressure Treatment

Treat woodwork and millwork, such as exterior trim, door trim, and window trim, in accordance with WDMA I.S. 4, with either 2 percent copper napthenate, 3 percent zinc napthenate, or 1.8 percent copper-8-quinolinolate. Provide a liberal brush coat of preservative treatment to field cuts and holes.

2.7.2 Pressure Treatment

Lumber and plywood used on the exterior of buildings or in contact with masonry or concrete shall be treated with water-borne preservative listed in AWPA P5 as applicable, and inspected in accordance with AWPA M2. Identify treatment on each piece of material by the quality mark of an agency accredited by the Board of Review of the American Lumber Standards Committee. Plywood shall be treated to a reflection level as follows:

Exterior wood molding and millwork within 455 mm (18 inches) of soil, in contact with water or concrete shall be preservative-treated in accordance with WMMPA WM 6. Exposed areas of treated wood that are cut or drilled after treatment shall receive a field treatment in accordance with AWPA M4. Items of all-heart material of cedar, cypress, or redwood will not require preservative treatment, except when in direct contact with soil.

2.8 FIRE-RETARDANT TREATMENT

2.8.1 Wood Products

Fire-retardant treated lumber shall be pressure treated in accordance with AWPA C20. Fire-retardant treated plywood shall be pressure treated in accordance with AWPA C27. Material use shall be defined in AWPA C20 and AWPA C27 for Interior Type A and B and Exterior Type. Treatment and performance inspection shall be by a qualified independent testing agency that establishes performance ratings. Each piece or bundle of treated material shall bear identification of the testing agency to indicate performance with such rating. Treated materials to be exposed to rain wetting shall be subjected to an accelerated weathering technique in accordance with ASTM D2898, Method A, prior to being tested for compliance with AWPA C20 or AWPA C27.

Treat items indicated on contract drawings.

2.9 HARDWARE

Provide sizes, types, and spacings of manufactured building materials recommended by the product manufacturer except as otherwise indicated or specified.

2.9.1 Wood Screws

ASME B18.6.1.

2.9.2 Bolts, Nuts, Lag Screws, and Studs

ASME B18.2.1 and ASME B18.2.2.

2.9.3 Nails

Nails shall be the size and type best suited for the purpose and shall conform to ASTM F547 or KS D 3553. Nails shall be hot-dip galvanized or aluminum when used on exterior work. For siding, length of nails shall be sufficient to extend 40 mm (1-1/2 inches) into supports, including wood sheathing over framing. Screws for use where nailing is impractical shall be size best suited for purpose.

2.9.4 Adjustable Shelf Standards

ANSI/BHMA A156.9.

2.9.5 Vertical Slotted Shelf Standards

ANSI/BHMA A156.9.

2.9.6 Closet Hanger Rods

Chromium-plated steel rods, not less than 25 mm (1 inch) diameter by 1.3 mm thick (18 gage). Rods may be adjustable with integral mounting brackets if smaller tube is 25 mm (1 inch) by 1.3 mm thick (18 gage). Provide intermediate support bracket for rods more than 1200 mm (48 inches) long.

2.10 FABRICATION

2.10.1 Quality Standards (QS)

The terms "Premium," "Custom," and "Economy" refer to the quality grades defined in AWI AWS. Items not specified to be of a specific grade shall be Custom grade. The AWI QS is superseded by all contract document requirements indicated or stated herein.

2.10.2 Countertops

Fabricate with lumber and a core of exterior plywood or particleboard, glued and screwed to form an integral unit. Bond laminated plastic under pressure to exposed surfaces, using type of glue recommended by plastic manufacturer , and bond a backing sheet under pressure to underside of countertop, unless otherwise indicated. Countertop unit shall be post-formed type with no-drip nose, cove moulding, and Style A back splash, and covered with ANSI/NEMA LD 3, Grade PF 42 plastic. Back splash shall be not less than 90 mm (3-1/2 inches) or more than 115 mm (4-1/2 inches) high.

2.10.3 Cabinets

Wall and base cabinets and vanity cabinets shall be of the same construction and appearances. Fabricate with solid ends and frame fronts, or with frames all around. Frames shall be solid hardwood not less than 19 by 38 mm (3/4 by 1-1/2 inches). Ends, bottom, back, partitions, and doors shall be hardwood plywood. Mortise and tenon, dovetail, or dowel and glue joints to produce a rigid unit. Cover exposed edges of plywood with hardwood strips. Doors, frames, and solid exposed ends shall be 19 mm (3/4 inch) thick; bottom, partitions, and framed ends 13 mm (1/2 inch) minimum; shelves 16 mm (5/8 inch) minimum; back 6 mm (1/4 inch) minimum.

2.10.3.1 Cabinet Hardware

ANSI/BHMA A156.9. Provide cabinet hardware including two self-closing hinges for each door, two side-mounted metal drawer slides for each drawer and pulls for all doors and drawers as follows. Hardware exposed to view shall be bright chromium plated, unless otherwise indicated. All cabinet hardware shall comply with the following requirements:

a. Provide concealed Euro-Style, back mounted hinges with opening to 165 degrees with self-closing feature at less than 90 degrees to its closed position.

b. Drawer slides shall have a static rating capacity of 444 N (100 lbs). The slides shall have a self closing/stay-closed action, zinc or epoxy coated steel finish, ball bearing rollers, and positive stop with lift out design.

c. Drawer pulls shall be wire type pulls with center-to-center dimension not less than 89 mm (3-1/2 inches) and cross sectional diameter of 8 mm (5/16 inch). The handle projection shall be not less than 33 mm (1-5/16 inches).

d. Drawer catch shall be heavy duty magnetic catch.

2.10.3.2 Finish

Provide a natural factory finish on wood surfaces after fabrication. Finish shall be fabricator's standard natural finish, except that it shall be equivalent to one coat of sealer and one coat of spar varnish on all surfaces and a second coat of spar varnish on surfaces exposed to view. Sand lightly and wipe clean between coats.

2.10.4 Workbenches

Fabricate as indicated. Dovetail and glue drawer corners. Fasten frames with suitable wood screws or bolts. Sand exposed surfaces smooth, and ease exposed edges. Provide two side-mounted, metal, ball-bearing drawer slides for each drawer, and at least two surface-mounted hinges and a magnetic catch for each door.

2.10.5 Casework With Transparent Finish (CTF)

2.10.5.1 AWI Quality Grade (CTF)

Premium grade.

2.10.5.2 Construction (CTF)

Details shall conform to reveal overlay, flush overlay, or exposed face frame design.

2.10.5.3 Exposed Parts

Specie and cut as indicated on contract drawings.

2.10.5.4 Semi-Exposed Parts

As specified in the AWI AWS for the grade selected.

2.10.6 Casework With High Pressure Laminate Finish (CHPL)

2.10.6.1 AWI Quality Grade (CHPL)

Premium grade.

2.10.6.2 Construction (CHPL)

Details shall conform to reveal overlay, flush overlay, or exposed face frame design.

2.10.6.3 Exposed Surfaces

High pressure laminate.

2.10.6.4 Semi-Exposed Surfaces

As specified in the AWI AWS for the grade selected.

2.11 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 FINISH WORK

Provide sizes, materials, and designs as indicated and as specified. Apply primer to finish work before installing. Where practicable, shop assemble and finish items of built-up millwork. Joints shall be tight and constructed in a manner to conceal shrinkage. Miter trim and moldings at exterior angles and cope at interior angles and at returns. Material shall show no warp after installation. Install millwork and trim in maximum practical lengths. Fasten finish work with finish nails. Provide blind nailing where practicable. Set face nails for putty stopping.

3.1.1 Exterior Finish Work

Machine-sand exposed flat members and square edges. Machine-finish semi-exposed surfaces. Construct joints to exclude water. In addition to nailing, glue joints of built-up items with waterproof glue as necessary for weather-resistant construction. Provide well distributed end joints in built-up members. Provide shoulder joints in flat work. Hold backs of wide-faced miters together with metal rings and waterproof glue. Fascias and other flat members shall be 19 mm (3/4 inch) thick, unless otherwise indicated in contract drawings. Provide door and window trim in single lengths. Provide braced, blocked, and rigidly anchored cornices for support and protection of vertical joints. Install soffits in largest practical size. Joints of plywood shall occur over center lines of supports. Fasten soffits with aluminum or stainless steel nails. Back prime all concealed surfaces of exterior trim.

3.1.2 Interior Finish Work

After installation, sand exposed surfaces smooth. Provide window and door trim in single lengths.

3.1.3 Door Frames

Set plumb and square. Provide solid blocking at not more than 400 mm (16 inches) o.c. for each jamb. Position blocking to occur behind hinges and lock strikes. Double wedge frames and fasten with finishing nails. Set nails for putty stopping.

3.1.4 Thresholds

Provide thresholds 16 mm (5/8 inch) thick by 70 mm (2-5/8 inches) wide with beveled sides and cut to fit at jambs. Fasten thresholds with casing nails. Set nails for putty stopping.

3.1.5 Window Stools and Aprons

Provide stools with rabbet over window sill. Provide aprons with returns cut accurately to profile of member.

3.1.6 Bases

Flat member with a molded top and oak shoe mold. Fasten base to framing or to grounds. Nail shoe mold to the base. Set shoe mold or one-piece wood base after finish flooring is in place.

3.1.7 Finish Stair Work

Fit, nail, screw, bolt, and glue stair work together to form a strong rigid structure without squeaks or vibrations. Anchor newels and posts securely to rough stair framing. Cut newels, posts, and drops accurately around floor construction to make tight fit. Install balusters into treads and landings with glue. Install railing with straight runs following slope of stairs and with smooth curve turns. Return railing profile at ends and secure joints with bolts and nuts. Secure railing to posts and newels with concealed anchors. Support wall rails on metal brackets spaced near ends and not over 1500 mm (5 feet) o.c.

3.2 SHELVING

19 mm (1 inch nominal) thick wood shelf material or 19 or 20 mm (3/4 or 23/32 inch) thick plywood shelf material supported substantially with end and intermediate supports and arranged to prevent buckling and sagging. Provide cleats except where hook strips are specified or indicated. Where adjustable shelving is indicated, provide standards and brackets or shelf rests for each shelf. Anchor standards to wall at not more than 600 mm (2 feet) o.c.

3.2.1 Linen Closets

Unless indicated otherwise, linen closets shall have a counter shelf 500 mm (20 inches) wide located 900 mm (36 inches) above the floor, a lower shelf approximately 450 mm (18 inches) wide and 450 mm (18 inches) above the floor, and three upper shelves 285 mm (11-1/4 inches) wide located 350 mm (14 inches) above the counter shelf and 350 mm (14 inches) apart.

3.2.2 Storage Rooms

Provide storage rooms with shelves of size and arrangement as indicated.

3.2.3 Room Closets

Provide two shelves 285 mm (11-1/4 inches) wide. Support lower shelf by hook strips at back and ends, and provide full-length wood or metal clothes hanger rods unless indicated otherwise.

3.2.4 Cleaning-Gear Closets

Provide shelves of size and arrangement indicated.

3.3 CLOTHES HANGER RODS

Provide clothes hanger rods where indicated and in closets having hook strips. Set rods parallel with front edges of shelves and support by sockets at each end and by intermediate brackets spaced not more than 1200 mm (4 feet) o.c.

3.4 MISCELLANEOUS

3.4.1 Counters

Construct as indicated. Conceal fastenings where practicable, fit counter neatly, install in a rigid and substantial manner, and scribe to adjoining surfaces. Provide counter sections in longest lengths practicable; keep joints in tops to a minimum; and where joints are necessary, provide tight hairline joints drawn up with concealed-type heavy pull-up bolts. Glue joints with water-resistant glue and, in addition, make rigid and substantial with screws, bolts, or other approved fastenings.

3.4.2 Cabinets

Install level, plumb, and tight against adjacent walls. Secure cabinets to walls with concealed toggle bolts, and secure top to cabinet with concealed screws. Make cut-outs for fixtures to templates supplied by fixture manufacturer. Carefully locate cut-outs for pipes so that edges of holes will be covered by escutcheons.

3.4.3 Workbenches

Construct as indicated. Install level, plumb, and tight against adjacent construction. Fasten to walls with screws or toggle bolts and to floors with expansion bolts.

3.4.4 Wood Seats

Support seats on brackets spiked to the studs, unless otherwise indicated. Secure seats to supports with screws or bolts as required; countersink heads of screws or bolts and fill holes with hardwood filler, finished flush with tops of seats.

3.4.5 Wood Bumpers

Bore, countersink, and bolt in place where indicated.

3.4.6 Catwalks in Attic Spaces

Lay boards with 25 mm (1 inch) spaces between. Stagger end joints, with each joint on a support.

3.5 SIDING

3.5.1 Installation of Siding

Fit and position without springing or otherwise forcing into place. For siding to have a stain finish, set nails and stop with nonstaining putty to match finished siding. For siding to have a paint finish, drive nails flush.

3.5.2 Horizontal Siding

Make end joints over framing members and alternate so at least two boards will be between joints on same support. Uniformly distribute shorter pieces throughout area. Provide starter strips to establish proper slant for siding. Predrill ends of siding if necessary to prevent splitting when nailed. Horizontal bevel or plain lap siding: Overlap and nail into each support in accordance with recommendations of siding manufacturer. Horizontal drop siding: Work each course into top edge of previous course. Nail into each support with two nails, one near lower edge to clear top of previous course, and one just above mid-height of course.

3.5.3 Vertical Board Siding

Apply siding with horizontal joints only at locations indicated. Work each board into edge of previous course. Nail into supports at 600 mm (24 inches) on center with two nails, one blind if possible at or near joint with previous board, and one just outside board centerline.

3.5.4 Vertical Board and Batten Siding

Apply with horizontal joints only at locations indicated. Install each board with 13 mm (1/2 inch) space between it and previous board. Nail at center of board and into supports at 600 mm (24 inches) on center. Center battens over space between boards and nail down center at 400 mm (16 inches) on center.

3.5.5 Panel Siding

Apply panels with edges at joints spaced in accordance with manufacturer's recommendations. Shiplapped edges or square edges covered with battens shall be primed for paint finish or sealed for stain finish, as indicated. Back all edges with framing members. Nail panels at edges 150 mm (6 inches) on center and at intermediate supports 300 mm (12 inches) on center. Edge nailing to be 10 mm (3/8 inch) from edges. For shiplap joints, nail 10 mm (3/8 inch) from visible joint and at a location to penetrate lap with previous panel. When panel siding is part of an engineered shear wall or used as wall-bracing, nail shiplap joints to supports with double rows of nails. Space battens at 300 mm (12 inches) on center and nail down center at 600 mm (24 inches) on center.

3.5.6 Epoxy-Aggregate Coated Panels

Panels shall be installed where shown. Installation shall be as recommended by the manufacturer of the panels.

3.6 SOFFITS

3.6.1 Wood

Panels shall be applied with edges at joints spaced in accordance with manufacturer's instructions and with all edges backed with framing members. Panels shall be nailed 10 mm (3/8 inch) from edges at 150 mm (6 inches) on center and at intermediate supports at 300 mm (12 inches) on center. Panels shall be installed using the maximum practical lengths.

3.7 FASCIAS AND EXTERIOR TRIM

Exposed surfaces and square edges shall be machine sanded, caulked, and constructed to exclude water. Joints of built-up items, in addition to nailing, shall be glued as necessary for weather-resistant construction. End joints in built-up members shall be well distributed. Joints in flat work shall be shouldered. Backs of wide-faced miters shall be held together with metal rings and glue. Fascias and other flat members shall be in maximum practicable lengths. Cornices shall be braced, blocked, and rigidly anchored for support and protection of vertical joints.

3.8 MOLDING AND INTERIOR TRIM

Molding and interior trim shall be installed straight, plumb, level and with closely fitted joints. Exposed surfaces shall be machine sanded at the mill. Molded work shall be coped at returns and interior angles and mitered at external corners. Intersections of flatwork shall be shouldered to ease any inherent changes in plane. Window and door trim shall be provided in single lengths. Blind nailing shall be used to the extent practicable, and face nailing shall be set and stopped with a non-staining putty to match the finish applied. Screws shall be used for attachment to metal; setting and stopping of screws shall be of the same quality as required where nails are used.

3.9 WOOD SHINGLES

Wood shingles shall be applied by single-coursing method and with a weather exposure of 215 mm (8-1/2 inches). Each shingle shall be nailed with two nails 25 mm (1 inch) above butt line of the next course, except shingles more than 200 mm (8 inches) in width shall be nailed with three nails. Starter course shall be doubled, and vertical joints shall be offset from vertical joints of the previous course. Corners shall be mitered over flashing or abutted to a cedar or redwood strip at the corner as indicated.

-- End of Section --

SECTION 07 11 13

BITUMINOUS DAMPPROOFING
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C208	(2008a) Cellulosic Fiber Insulating Board
ASTM C728	(2005; R 2010) Perlite Thermal Insulation Board
ASTM D1187/D1187M	(1997; R 2011e1) Asphalt-Base Emulsions for Use as Protective Coatings for Metal
ASTM D1227	(1995; R 2007) Emulsified Asphalt Used as a Protective Coating for Roofing
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D227/D227M	(2003e1; R 2011) Coal-Tar-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D4263	(1983; R 2012) Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4479	(2007) Asphalt Roof Coatings - Asbestos-Free
ASTM D449	(2003; R 2008) Asphalt Used in Dampproofing and Waterproofing

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926	Safety and Health Regulations for Construction

KOREAN INDUSTRIAL STANDARDS (KS)

KS M 2270	(2007) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-07 Certificates

Materials

1.3 DELIVERY AND STORAGE

Deliver materials in sealed containers bearing manufacturer's original labels. Labels shall include date of manufacture, contents of each container, performance standards that apply to the contents and recommended shelf life.

1.4 SAFETY AND HEALTH REQUIREMENTS

If coal-tar pitch materials are used, the Contractor shall conform to all OSHA 29 CFR 1926 and General Industry Health Standards as well as state and local standards.

PART 2 PRODUCTS

2.1 ASPHALT

ASTM D449, Type I or Type II.

2.2 ASPHALT PRIMER

ASTM D41/D41M or KS M 2270.

2.3 FIBROUS ASPHALT

ASTM D4479, Type I for horizontal surfaces, Type II for vertical surfaces.

2.4 EMULSION-BASED ASPHALT DAMPPROOFING

2.4.1 Fibrated Emulsion-Based Asphalt

Fibrated emulsion-based asphalt dampproofing shall be cold-applied type conforming to ASTM D1227 Type II, Class 1, asbestos-free, manufactured of refined asphalt, emulsifiers and selected clay, fibrated with mineral fibers. For spray or brush application, emulsion shall contain a minimum of 59 percent solids by weight, 56 percent solids by volume. For trowel application, emulsion shall contain a minimum of 58 percent solids by weight, 55 percent solids by volume.

2.4.2 Non-Fibrated Emulsion-Based Asphalt

Non-fibrated emulsion-based asphalt dampproofing shall be cold-applied type conforming to ASTM D1187/D1187M Type II or ASTM D1227 Type III, manufactured of refined asphalt, emulsifiers and selected clay. Asphalt shall contain a minimum 58 percent solids by weight, 55 percent solids by volume.

2.5 SURFACE PROTECTION

2.5.1 Saturated Felt

ASTM D226/D226M, Asphalt Saturated, Type I, 6.8 kilogram (15 pound); ASTM D227/D227M, Coal-Tar Saturated.

2.5.2 Protection Board

Wood Fiber Board, ASTM C208, or Perlite Board, ASTM C728.

2.6 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Remove or cut form ties and repair all surface defects as required in Section 03 30 00 CAST-IN-PLACE CONCRETE. Clean concrete and masonry surfaces to receive dampproofing of foreign matter and loose particles. Apply dampproofing to clean dry surfaces. Moisture test in accordance with ASTM D4263. If test indicates moisture, allow a minimum of 7 additional days after test completion for curing. If moisture still exists, redo test until substrate is dry.

3.1.1 Metal Surfaces

Metal surfaces shall be dry and be free of rust, scale, loose paint, oil, grease, dirt, frost and debris.

3.2 Protection of Surrounding Areas

Before starting the dampproofing work, the surrounding areas and surfaces shall be protected from spillage and migration of dampproofing material onto other work. Drains and conductors shall be protected from clogging with dampproofing material.

3.3 APPLICATION

Use either hot-application or cold-application method. Use cold-application method in confined spaces where hot bitumen would be hazardous. Prime surfaces to receive fibrous asphaltic dampproofing unless recommended otherwise by dampproofing materials manufacturer. Apply dampproofing after priming coat is dry, but prior to any deterioration of primed surface, and when ambient temperature is above 4 degrees C (40 degrees F).

3.3.1 Surface Priming

Prime surfaces to receive coal-tar pitch dampproofing with creosote primer. Prime surfaces to receive asphalt or fibrous asphalt dampproofing with asphalt primer. Apply primer when ambient temperature is above 4 degrees C (40 degrees F) and at rate of approximately four liters per 10 square meters (one gallon per 100 square feet), fully covering entire surface to be dampproofed.

3.3.2 Hot-Application Method

Apply two mop coats of hot coal-tar pitch or two mop coats of hot asphalt to surfaces. Apply mop coats uniformly using not less than 12.2 kilograms (25 pounds) of coal-tar pitch or 9.8 kilograms (20 pounds) of asphalt per 10 square meters (100 square feet) for each coat. Do not heat asphalt above 232 degrees C (450 degrees F). Do not heat coal tar pitch above 204 degrees C (400 degrees F). Have kettlemen in attendance at all times during heating to ensure that maximum temperature specified is not exceeded. Apply hot asphalt bitumen or coal tar pitch and fully bond to primed surface. Provide finished surface that is smooth, lustrous, and impervious to moisture. Recoat dull or porous spots.

3.3.3 Cold-Application Method

3.3.3.1 Fibrous Asphalt

Apply two coats of fibrous asphalt to surfaces to be dampproofed. Apply each coat uniformly using not less than four liters (one gallon) fibrous asphalt per 5 square meters (50 square feet). Apply first coat by brush or spray to provide full bond with primed surface. Brush or spray second coat over thoroughly dry first coat unless recommended otherwise by dampproofing materials manufacturer. Provide finished surface that is of uniform thickness and impervious to moisture. Recoat porous areas.

3.3.3.2 Emulsion-Based Asphalt

Emulsion-based asphalt dampproofing work shall not be performed in temperatures below 4 degrees C (40 degrees F). Emulsions shall have a smooth and uniform consistency at time of application. Dampproofing materials shall be applied in accordance with manufacturer's published instructions to produce a smooth uniform dry film of not less than0.3 mm (12 mils) thick without voids or defects. Dull or porous spots shall be recoated. Dampproofing materials shall seal tightly around pipes and other items projecting through dampproofing. Rates of application shall be as follows:

a. Primer: 0.2 liters per square meter (1/2 gallon per 100 square feet), cold-applied.

b. Fibrated Dampproofing: 0.8 liters per square meter (2 gallons per 100 square feet), cold-applied with spray, brush or trowel.

c. Non-fibrated Dampproofing: 0.8 liters per square meter (2 gallons per 100 square feet), cold-applied with spray, brush or trowel.

3.4 PROTECTIVE COVERING

Protect dampproofed surfaces against which backfill will be placed with one layer of 6.8 kilogram (15 pound saturated felt conforming to the requirements specified herein. Use asphalt-saturated felt where the dampproofing material is asphalt and use coal-tar-saturated felt where the dampproofing material is coal-tar pitch. Embed felts in the second coating of bitumen and lap edges and ends not less than 25 mm (one inch .

-- End of Section --

SECTION 07 12 00

BUILT-UP BITUMINOUS WATERPROOFING
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C208	(2008a) Cellulosic Fiber Insulating Board
ASTM C726	(2011) Mineral Fiber Roof Insulation Board
ASTM D1327	(2004) Bitumen-Saturated Woven Burlap Fabrics Used in Roofing and Waterproofing
ASTM D1668	(1997a; R 2006) Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
ASTM D173/D173M	(2003e1; R 2011) Bitumen-Saturated Cotton Fabrics Used in Roofing and Waterproofing
ASTM D2178	(2004) Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D449	(2003; R 2008) Asphalt Used in Dampproofing and Waterproofing
ASTM D4586	(2007) Asphalt Roof Cement, Asbestos-Free
ASTM D517	(1998; R 2008) Asphalt Plank

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3200	(2006) Fiberboards
KS F 4052	(2004) Waterproofing Asphalts for Building Construction
KS F 4913	(2006) Woven Fabrics Asphalt Roofing
KS M 2270	(2007) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office

that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Protection board
Prefabricated copper fabric
Membrane fabric

SD-06 Test Reports

Liquid asphalt

1.3 ENVIRONMENTAL CONDITIONS

Apply the primers and waterproofing specified herein when the ambient temperature is above 4 degrees C (40 degrees F).

1.4 DELIVERY AND STORAGE

1.4.1 Packaged Materials

Deliver materials in bundles, rolls, and sealed containers bearing the manufacturer's original labels. Asphalt shall be protected from freezing in a weathertight enclosure. Store materials in an enclosed area free from contact with soil and weather, and maintain at not less than 10 degrees C (50 degrees F) for at least 24 hours before use. Reinforcement fabrics shall be protected from moisture damage and moisture absorption in a weathertight enclosure or shall be stored off the ground on pallets, and covered on top and all sides with breathable-type canvas tarpaulins. Plastic sheets cause condensation buildup and therefore shall not be used to cover waterproofing materials. If material is dated for use or shelf life is indicated on the labels, remove outdated material from the jobsite. Damaged or deteriorated materials shall be removed from project site.

1.4.2 Liquid Asphalt

Deliver bulk liquid asphalt in fully insulated, heated transport tanker vehicles with circulating pump devices. Maintain the temperature of the liquid asphalt between 204 and 232 degrees C (400 and 450 degrees F) during storage, provided the transport and storage time does not exceed 12 hours. If the transport and storage time exceeds 12 hours, lower the temperature to between 150 and 165 degrees C (300 and 325 degrees F) at the time the 12 hours are exceeded. Liquid asphalt shall be used within 36 hours after loading in the transport tanker.

Submit certified laboratory reports on the results of tests performed on asphalt delivered to the construction site by bulk liquid asphalt tankers.

1.4.2.1 Asphalt Shipment Records

Obtain from the bulk liquid asphalt manufacturer a certified statement with each shipment of asphalt. Following completion of the waterproofing, submit the certificates to the Contracting Officer for record keeping purposes. Indicate the following:

a. Manufacturer's name

b. Specification identification of asphalt.

c. Quantity of asphalt

d. Transport tanker was empty and free of foreign and non-compatible material at the time of loading

e. Date and time of loading

f. Temperature of asphalt at time of loading

PART 2 PRODUCTS

2.1 BITUMEN

Asphalt; ASTM D449 or KS F 4052.

2.2 BITUMINOUS PLASTIC CEMENT

ASTM D4586, Type I or II for asphalt.

2.3 MEMBRANE FABRIC

The following requirements shall apply:

Felt or Fabric Material	Saturant or Impregnant	Specification
Glass (felt) mat	Asphalt	ASTM D2178, Type III
Reinforcing glass fabric	Asphalt	ASTM D1668, Type I
Reinforcing cotton fabric	Asphalt	ASTM D173/D173M
Reinforcing woven burlap fabric	Asphalt	ASTM D1327

2.3.1 Cotton Fabrics

Cotton fabrics shall be woven entirely of cotton conforming with ASTM D173/D173M, thoroughly and uniformly saturated with asphalt.

2.3.2 Woven Burlap Fabrics

Woven burlap fabrics shall be composed of 100 percent jute fiber and two cotton threads at each selvage conforming with ASTM D1327 or KS F 4913, thoroughly and uniformly saturated with asphalt. The fabric mesh shall not be completely closed or sealed by the process of saturation. Sufficient porosity shall be maintained to allow successive moppings of the plying asphalt to seep through. The surface shall not be coated or covered with talc or any other substances that will interfere with the adhesion between fabric and plying asphalt. The fabric surface shall be uniformly smooth and free of irregularities, folds and knots. The finished woven burlap fabrics shall be free of ragged edges, untrue edges, breaks or cracks, and other visible external defects.

2.4 NAILS

Galvanized roofing nails.

2.5 PRIMER

ASTM D41/D41M or KS M 2270 for asphalt.

2.6 PROTECTION BOARD

ASTM D517, plain, asphalt plank; ASTM C208 or KS F 3200, construction grade building board, 12.7 mm (1/2 inch) thick, asphalt saturated or coated; ASTM C726, 11 mm (7/16 inch) thick, covered on one side with waterproof paper or asphalt-saturated felt.

2.7 PREFABRICATED LAMINATED ASPHALT WATERPROOFING

Prefabricated laminated construction consisting of plies of kraft paper bonded by layers of bitumen reinforced with layers of fibrous glass and one layer of polyethylene facing. Material and weight shall be as follows:

a. One layer polyethylene facing, 13.6 kgs (30 lbs.) ream weight; seven intermediate layers of bituminous-saturated kraft paper

b. Seven layers of bitumen

c. Three layers of 8.8 per 10 mm (20.20) fibrous glass mesh

d. Bottom "cushion" sheet of crepe kraft paper

e. Total minimum weight of materials of 1.95 kgs per square meter (0.40 lbs. per square foot)

f. Minimum bituminous content of 75 percent by weight

g. Permanently pliable and impervious to mildew and other organic attack, including termites and rodents

h. Puncture resistant and self-sealing.

2.8 PREFABRICATED COPPER FABRIC SHOWER PANS

A factory-fabricated sheet of copper bonded to and between two layers of asphalt-impregnated fiberglass or cotton fabric. Copper sheet shall weigh 1.52 kilograms per square meter (5 ounces per square foot), unless otherwise indicated.

2.9 WOOD NAILERS

Specified in Section 06 10 00 ROUGH CARPENTRY.

2.10 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSPECTION OF SURFACES

Before starting the work, inspect all surfaces to be waterproofed to determine if in satisfactory condition. Check the location and setting of all embedded items. Place backing and blocking and perimeter framing for recessed items as required by the various trades on the project. Complete conduit, piping, and other required rough-in. Notify the Contracting Officer of serious defects or conditions that will prevent satisfactory application. Start application after such defects and conditions have been corrected.

3.2 PREPARATION OF SURFACES

Surfaces to be treated shall be clean and dry, smooth and free from deleterious and excess materials and projections. Masonry surfaces shall be free of oil, grease, dirt, laitance, loose and broken material, frost, debris and other contaminants. Concrete surfaces shall be properly cured, free of release agents, oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Thoroughly wet holes, joints, cracks, and voids in concrete with water, and then carefully fill with portland cement mortar, strike flush, and permit to dry. Cut off or grind smooth high spots. Mortar joints in masonry walls shall be flush and free of extraneous mortar. Give surfaces to receive asphalt membrane waterproofing a priming coat of asphalt primer. Apply priming coat at a rate not less than 4 liters per 10 square meters (one gallon per 100 square feet), covering the entire surface to be waterproofed. Allow primer to dry before applying waterproofing.

3.3 APPLICATION

Install waterproofing where indicated. At the Contractor's option, shower pans of prefabricated laminated asphalt waterproofing or prefabricated copper fabric shower pan, as specified herein, may be used instead of bituminous membrane waterproofing. Provide ventilation for enclosed spaces when using bituminous membrane waterproofing.

3.3.1 Prefabricated Pan

Prefabricated Laminated Asphalt Waterproofing or Prefabricated Copper Fabric Shower Pan: Form each shower pan from a single piece of the laminated material without joints and with no opening except for shower drain. Install pan in accordance with the manufacturer's printed instructions.

3.3.2 Protection of Surrounding Areas

Before starting the waterproofing work, the surrounding areas and surfaces shall be protected from spillage and migration of asphalt onto other work. Drains and conductors shall be protected from clogging with asphalt.

3.3.2.1 Fired Kettles

Melt kettles for bitumen shall not be closer than 8 meters (25 feet) to buildings or combustible materials. Provide minimum of two 9 kilogram (20 pound) ABC all-purpose type extinguishers at melting kettle and area of hot material application. Equip kettles with automatic thermostatic control capable of maintaining asphalt temperature. Controls shall be calibrated and maintained in working order for duration of work. Equip kettles with means of agitation to ensure controlled uniform temperature throughout contents to prevent spot heating. Do not heat contents above flash point.ext

3.3.2.2 Heating and Application of Bitumen Coatings

Heat solid bitumen in kettle, equipped with an automatic heating device or control unit for positive control of the specified temperature. Provide an accurate and clearly readable thermometer on all kettles. Bulk liquid asphalt may be heated using the heating equipment in the transport tanker vehicle or transferred to kettles and heated as specified for solid bitumen. Heat bitumen to flow freely but not above 190 degrees C (375 degrees F). Apply bitumen over the primer, between each ply and as a top coating at the rate of not less than 10 kilograms (20 pounds) of asphalt per 10 square meters (100 square feet) of surface.

3.3.3 Membrane Waterproofing

3.3.3.1 Below-Grade Wall Waterproofing

Waterproofing for foundation walls shall consist of a 2-ply hot-applied asphalt membrane system. Fabrics shall be installed using the "shingle" method. Joints shall be caulked prior to primer applications. Primer shall be applied at a rate of 0.2 liters per square meter (1/2 gallon per 100 square feet). Fabrics shall be overlapped at ends and staggered a minimum 480 mm (19 inches) for 2-ply system. End-to-end taping is not acceptable. Each fabric shall be firmly embedded into a solid uniform coating of hot asphalt at a rate of 0.98 kg per square meter (20 lbs. per 100 square feet) by pressing with broom. Fabrics shall not touch fabrics. Hot asphalt shall penetrate each fabric to provide the required adhesion. Asphalt between fabrics shall not be excessive to prevent slippage. Waterproofing system consisting of two or more fabrics shall be provided with fabric reinforcement at corners, angles, over construction joints, and in locations where waterproofing fabrics are subject to unusual stress.

3.3.3.2 Floor Waterproofing

Primer shall be applied at a rate of 0.2 liters per square meter (1/2 gallon per 100 square feet). Primer shall not be left in puddles. Primer shall be dry to the touch before application of asphalt. Where slab abuts walls, first reinforcing fabric shall extend 150 mm (6 inches) minimum on slab and 200 mm (8 inches) on wall. At vertical corners, first fabric shall extend minimum 125 mm (5 inches) from corner on each side. Second fabric shall lap the first fabric 50 mm (2 inches) minimum. At floor drains, and elsewhere as indicated, the fabric shall extend into a clamping device, set in a heavy coating of flashing cement, and securely clamped.

3.3.4 Fabric Membrane Reinforcement

Provide fabric membranes to reinforce felts at intersections. Provide reinforcement consisting of two plies of fabric membrane cemented in place and to each other with bituminous plastic cement not less than 2 mm (1/16 inch) thick for each coating. At the intersection of slabs and vertical surfaces, extend the first ply at least 150 mm (6 inches) on the slab and 100 mm (4 inches) up the vertical surface. At intersections of two vertical surfaces, extend the first ply at least 250 mm (10 inches) on each side of the intersection. Place second ply to lap the first by not less than 50 mm (2 inches).

3.3.5 Keyed Joint Footings

Provide membrane flashing, neatly formed, to the contours of keyed joints in foundation wall footings. Extend flashing to the outside edge of the footing, and turn the flashing down 100 mm (4 inches). Continue the flashing through the joint to the inside of the walls and lap the flashing into the waterproofing membrane under the slab. Protect the flashing until it is lapped by the waterproofing membranes for the subsurface floor slabs and foundation walls. The flashing membrane shall be made up of the same number and type materials as the waterproofing membrane or a thermoplastic material compatible with the waterproofing materials, as recommended by the manufacturer.

3.3.6 Flashing Flanges

Prime flashing flanges of the sleeves of pipes and ducts penetrating the waterproofing membrane. Allow primer to dry. Strip flanges in with two fabric membrane collars cemented in place and to each other with bituminous plastic cement. Extend collars 100 and 150 mm (4 and 6 inches), respectively, beyond the edge of the flanges, cover the flanges, and fit the flanges tight against the sleeve. Extend waterproofing connecting with work exposed to the weather back of same, or counter flash to form a watertight connection.

3.3.7 Clamping Devices

At floor drains and elsewhere, as indicated, extend membrane into clamping device set in heavy coating of bituminous plastic cement, and clamp securely.

3.3.8 Reglets

Install continuous reglets as specified in Section 07 60 00 FLASHING AND SHEET METAL to receive the exposed edges of membrane waterproofing. After placement of waterproofing, completely fill reglets with bitumen.

3.4 FIELD TEST

3.4.1 Sampling and Testing of Bulk Liquid Asphalt

Notify the Contracting Officer one working day prior to the delivery date of asphalt. Take a minimum of one quart sample of each shipment of bulk liquid asphalt when the shipment arrives at the construction site. Obtain samples in the presence of the Contracting Officer using clean one-quart, friction-lid cans. Label samples to indicate project contract number, location where used on project, and date and time of arrival of shipment from which sample is taken. Give samples to the Contracting Officer for safekeeping until picked up by the testing laboratory. The Contractor shall pay for the testing of the bulk liquid asphalt. Samples tested which are found not to be in conformance with specification requirements will constitute grounds for rejection. Remove and replace with new materials all waterproofing installed with asphalt from which the nonconforming samples were taken.

3.4.2 Test of Membrane Waterproofing

Prior to concealment, plug the drain and cover membrane waterproofing on horizontal surfaces over finished spaces with 75 mm (3 inches) of ponded water for 24 hours to test water tightness. Make careful measurement of the water level at the beginning and end of the 24-hour period. If water level falls, drain the water, and thoroughly dry and inspect the waterproofing membrane. Make repairs or replacement, as directed, and repeat test. Work which conceals membrane waterproofing shall not proceed before approval of test results.

3.5 PROTECTIVE COVERING

3.5.1 Vertical Surfaces

Protect membrane waterproofing against which backfill is to be placed by providing protective covering pressed into the final mopping while the mopping of bitumen is still hot. Butt edges of protection board against adjacent edges of protection boards. Cover exposed surfaces with a coating of bitumen. Where surfaced fiberboard or mineral fiberboard is used, place surface side facing outward. Fit board around pipes and projections so as to cover the entire surface of the membrane waterproofing.

3.5.2 Horizontal Surfaces

Place protective covering over membrane immediately after application has thoroughly dried. Remove protective covering immediately before proceeding with work which will conceal the membrane waterproofing.

3.6 CLEAN-UP

Surfaces of other work which are stained with waterproofing materials shall be cleaned with a cleaner recommended by waterproofing manufacturer.

3.7 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurement, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

Products	Inch-Pound	Metric
Protection Board	1/2 inch	12.7 mm
	7/16 inch	11 mm
Polyethylene Sheet	30 lbs.	13.6 kg
Laminated Sheet	0.40 lbs. per sq. ft	1.95 kg per sq. m

Products	Inch-Pound	Metric
Copper Sheet	3 oz/sq ft	0.92 kg/sq m
	5 oz/sq ft	1.52 kg/sq m
	7 oz/sq ft	2.14 kg/sq m

-- End of Section --

SECTION 07 13 53

ELASTOMERIC SHEET WATERPROOFING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1004	(2013) Initial Tear Resistance of Plastic Film and Sheeting
ASTM D1149	(2007; R 2012) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber
ASTM D1204	(2008) Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
ASTM D146	(2004; R 2012) Sampling and Testing Bitumen-Saturated Felts and Woven Fabrics for Roofing and Waterproofing
ASTM D1876	(2008) Standard Test Method for Peel Resistance of Adhesives (T-Peel Test)
ASTM D2136	(2002; R 2007) Coated Fabrics - Low-Temperature Bend Test
ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D297	(1993; R 2006) Rubber Products - Chemical Analysis
ASTM D3045	(1992; R 2010) Practice for Heat Aging of Plastics Without Load
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D429	(2008) Rubber Property-Adhesion to Rigid Substrates
ASTM D471	(2012) Standard Test Method for Rubber Property - Effect of Liquids

ASTM D5385	(1993; R 2006) Hydrostatic Pressure Resistance of Waterproofing Membranes
ASTM D570	(1998; E 2010; R 2010) Standard Test Method for Water Absorption of Plastics
ASTM D573	(2004; R 2010) Standard Test Method for Rubber - Deterioration in an Air Oven
ASTM D624	(2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM D746	(2007) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D751	(2006; R 2011) Coated Fabrics
ASTM D903	(1998; R 2010) Peel or Stripping Strength of Adhesive Bonds
ASTM E154	(2008a) Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Elastomeric waterproofing sheet material; G
Protection board
Primers, adhesives, and mastics

SD-06 Test Reports
Field Quality Control
Verification Of Conditions

SD-08 Manufacturer's Instructions

Primers, Adhesives and Mastics (MSDS)

1.3 QUALITY ASSURANCE

1.3.1 Shop Drawing Requirements

Include description and physical properties; termination details;

application details; recommendations regarding shelf life, application procedures; requirements for protective covering; and precautions for flammability and toxicity.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver and store materials out of the weather, in manufacturer's original packaging with brand name and product identification clearly marked. Do not permit uncertified materials in the work area.

1.5 ENVIRONMENTAL CONDITIONS

Do not apply waterproofing during inclement weather or when there is ice, frost, surface moisture, or visible dampness on the surface to receive waterproofing and when ambient and surface temperatures are 4 degrees C (40 degrees F) or below.

PART 2 PRODUCTS

2.1 MATERIALS

Provide one of the types of elastomeric waterproofing sheet material and related primers, adhesives, and mastics as specified herein. Ensure compatibility of waterproofing materials within a specific type, with each other, and with the materials on which they will be applied. Materials shall conform to the applicable performance requirements cited below when tested in accordance with the referenced ASTM publications.

Submit Manufacturer's material safety data sheets for primers, adhesives and mastics (MSDS).

2.2 BUTYL RUBBER SHEETING

Not less than 1.5 mm (60 mils) minimum thickness.

2.2.1 Butyl Rubber Sheeting Performance Requirements

a. Thickness Tolerance, ASTM D412: Plus or minus 10 percent

b. Specific Gravity, ASTM D297: 1.20, plus or minus 0.05

c. Tensile Strength, ASTM D412: 7.7 MPa (1200 psi) minimum

d. Tensile Stress at 300 percent elongation, ASTM D412: 3.85 MPa (600 psi) minimum

e. Elongation, ASTM D412: 300 percent minimum

f. Tear Resistance, Die C, ASTM D624: 26.3 Newtons per millimeter (N/mm) (150 pound force per inch (lbf/inch))minimum

g. Shore A Hardness, ASTM D2240: Five-second interval before reading; 60 plus or minus 10

h. Ozone Resistance, ASTM D1149: No cracks, 7 days - 50 ppm - 37.8 degrees C (100 degrees F), 20 percent elongation

i. Heating Aging-Accelerated, ASTM D573: Tensile retention, 60 percent of minimum original elongation retention; 60 percent of minimum original requirement; 7 days, 115.6 degrees C (240 degrees F)

j. Butyl Identification, ASTM D471, Tricresyl Phosphate Immersion: Maximum volume swell 10 percent, 70 hrs, 100 degrees C (212 degrees F)

k. Low Temperature Flexibility, ASTM D746: No failure at minus 40 degrees C (minus 40 degrees F)

l. Water Absorption, ASTM D471: plus 1 percent maximum. 7 days, 70 degrees C (158 degrees F)

m. Exposure to Fungi and Bacteria in Soil, ASTM E154, Minimum 16 Weeks: Unaffected

n. Water Vapor Transmission, 26.7 Degrees C (80 Degrees F)Permeance, ASTM E96/E96M, Procedure B or BW: 8.58 by 10-7 g/Pa.s.m2 (0.15 perms) maximum.

2.2.2 Adhesive, Cement, and Tape for Use with Butyl Rubber

As recommended by the butyl rubber waterproofing membrane manufacturer.

2.3 THERMOPLASTIC MEMBRANE: POLYVINYL CHLORIDE (PVC)

Polyvinyl chloride (PVC) flexible sheets with non-woven fiberglass reinforcing not less than 1.5 mm (60 mils) minimum thickness.

2.3.1 Thermoplastic Membrane Performance Requirements

a. Overall thickness, ASTM D751: 1.50 mm (.059 inches) min.

b. Tensile strength ASTM D638: 11.03 MPa (1600 psi) min.

c. Elongation at break, ASTM D638: 250 percent minimum

d. Seam strength, ASTM D638: 90 percent minimum of tensile strength

e. Retention of properties after heat aging, ASTM D3045

f. Tensile strength, ASTM D638: 95 percent of original

g. Elongation, ASTM D638: 95 percent of original

h. Tear resistance, ASTM D1004: 7.7 Kilogram Force (17 Pound Force)

i. Low Temperature Bend , ASTM D2136: minus 40 C (minus 40 F)

j. Liner Dimensional Change, ASTM D1204: 0.002 percent

k. Weight Change After Immersion in Water, ASTM D570: 2.0 percent maximum.

2.3.2 Adhesives

a. Adhesive for thermoplastic flashings as recommended by manufacturer.

b. Adhesive for Sub-Membrane Grid: 100 percent solids, two-part urethane, with minimum tensile strength of 1.04 MPa (150 psi), in accordance with ASTM D412 and adhesion to concrete of 12 ply in accordance with ASTM D429 as recommended by manufacture.

2.3.3 Accessories

Securement Strip: 14 gauge stainless steel metal bar 2.54 cm (1 inch) wide, pre-punched 2.54 cm (1 inch) on center for securement.

2.4 COMPOSITE, SELF-ADHERING MEMBRANE SHEETING

Cold applied composite sheet consisting of rubberized asphalt and cross laminated, high density polyethylene film. Not less than 1.5 mm (60 mils) minimum thickness is required.

2.4.1 Composite, Self-Adhering Sheeting Performance Requirements

a. Tensile Strength, ASTM D412, Die C: 1.6 MPa (250 psi) minimum

b. Ultimate Elongation, ASTM D412, Die C: 200 percent minimum

c. Water Vapor Transmission, ASTM E96/E96M 26.7 Degrees C (80 Degrees F) Permeance, Procedure B: 5.72 by 10-7 g/Pa.s.m2 (0.1 perm) maximum

d. Pliability Degrees F, ASTM D146: (180 Degrees Bend Over 25 mm (one inch) Mandrel): No cracks at minus 32 degrees C (minus 25 degrees F)

e. Cycling Over Crack at minus 26 degrees C (minus 15 Degrees F): Membrane is applied and rolled across two primed concrete blocks with no separation between blocks. Crack opened and closed from zero to 6 mm (1/4 inch). No effect at 100 cycles

f. Puncture Resistance, ASTM E154: 18 kg (40 lbs) minimum

g. Lap Adhesion at Minimum Application Temperature, ASTM D1876 Modified, 880 N/m (5 lbs/in.)

h. Peel Strength, ASTM D903: Modified 1576 N/m (9 lbs/n)

i. Resistance to Hydrostatic Head, ASTM D5385: 70 m (231 ft) of water

j. Water Absorption, ASTM D570; 0.1 percent maximum.

2.4.2 Primer

Asphalt composition, ASTM D41/D41M, or synthetic polymer in solvent as recommended by the membrane manufacturer.

2.4.3 Mastic

Polymer modified asphalt in suitable solvent of trowel-grade consistency and as recommended by the membrane manufacturer.

2.5 Protection Board

Provide protection board that is compatible with the waterproofing membrane. Use a minimum 13 mm 1/2 inch thick fir bituminous - impregnated board 25 mm (1 inch) for polystyrene 3 mm (1/8 inch) thick for vertical and 6 mm (1/4 inch) for horizontal premolded bituminous protection board as recommended by the manufacturer.

2.6 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

Before starting the work, verify that surfaces to be waterproofed are in satisfactory condition. Notify the Contracting Officer of defects or conditions that will prevent a satisfactory application. Do not start application until defects and conditions have been corrected.

3.2 SURFACE PREPARATION

Ensure surfaces to be treated are clean, dry, smooth, and free from deleterious materials and projections. Thoroughly wet holes, joints, cracks, and voids in masonry or concrete with water and fill with Portland cement mortar, strike flush, and permit to dry. Cut off high spots or grind smooth. Finish top surfaces of projecting masonry or concrete ledges below grade, except footings, to a steep bevel with Portland cement mortar. Sweep surfaces to be covered before applying waterproofing to remove dust and foreign matter. Cure concrete by a method compatible with the waterproofing system.

3.3 APPLICATION

Follow manufacturer's printed installation instructions. Where indicated, mop continuous cant strips in place at vertical and horizontal corners before installing the waterproofing membrane. Do not use untreated wood or wood fiber cants. When using solvent welding liquid, avoid prolonged contact with skin and breathing of vapor. Provide adequate ventilation. Carry waterproofing of horizontal surfaces up abutting vertical surfaces as indicated and adhere solid to the substrate. Avoid wrinkles and buckles in applying membrane and joint reinforcement.

a. Non-Self-Adhering Membrane: Unroll membrane and allow to remain flat for at least one-half hour before application. Apply an asphalt concrete primer prior to application of asphaltic adhesive. Where solvent adhesive is applied, allow major portion of solvent to evaporate so that bonding adhesive does not stick to a dry finger touching it. Apply elastomeric waterproofing membrane in a full bed of adhesive at a uniform coverage rate in accordance with the recommendations in the membrane manufacturer's printed instructions. Where membrane on horizontal surfaces are to receive concrete fill, apply adhesive in 100 mm (4 inch) wide strips at 600 mm (2 feet) on center. Pull membrane tight without stretching. As soon as adhesive is fully set and dry, recheck lap splices. Where openings or fishmouths appear, reseal and reroll lap splices.

b. Self-Adhering Membrane: Apply composite, self-adhering membrane on surfaces primed at a uniform coverage rate in accordance with membrane manufacturer's printed instructions. Remove release sheet and apply with tacky surface in contact with dried primer.

c. Protection: Protect membrane over horizontal surfaces from abnormal traffic during installation. Use only equipment with rubber tires. Provide walkway protection where heavy traffic from other trades is expected. Do not store material on membrane.

3.3.1 Butyl Rubber

Lap sheets at sides and ends a minimum of 150 mm (6 inches) over the preceding sheet. Apply lap splicing cement over entire 150 mm (6 inches) splice area prior to application of sealant. Sealant shall be continuous along the entire length of the splice. Maintain a continuous bead of sealant at all membrane splices or as required by the manufacturer. When membrane will be below water table, provide a tongue and groove cemented splice a minimum of 150 mm (6 inches) with factory made heat vulcanized seam not less than 50 mm (2 inches) or as required by the manufacturer.

3.3.2 Thermoplastic Membrane (PVC)

Deck shall be clean, smooth and dry without surface irregularities. Consult with membrane manufacturer prior to grid application. Install 30.48 cm (12 inches) wide sub-membrane containment grid as required by manufacturer. Provide and install the containment grid at intervals across the width and length of the substrate, at the base of all transitions, walls, curbs, penetrations, and at the perimeter of each deck/substrate section. Fully adhere strips to the deck in a full bedding of two-part urethane adhesive medium. Adjacent sheets shall be welded in accordance with manufacturer's instructions. All side and end lap joints shall be hot-air welded. Lap area shall be a minimum of 7.62 cm (3 inch) wide when machine welding, and a minimum of 10.16 cm (4 inch) wide when hand welding but not less than recommended by the manufacturer. Overlaps shall be with the flow of water.

3.4 Composite, Self-Adhering Membrane

Lap sheets at edges and ends a minimum of 65 mm (2-1/2 inches) over the preceding sheet. All side laps shall be minimum 65 mm (2-1/2 inches)and end laps shall be 127 mm (5 inches). Laps shall be self adhesive, mastic as per manufacturer's recommendation. Roll or firmly press to adhere membrane to substrate. Cover corners and joints with two layers of reinforcement by first applying a 300 mm (12 inch) width of membrane centered along the axis. Flash drains and projections with a second ply of membrane for a distance of 150 mm (6 inches) from the drain or projection. Finish exposed, terminated edges of membrane on horizontal or vertical surfaces with a trowelled bead of mastic. Apply mastic around edges of membrane, and drains and projections. Apply mastic at end of each work day.

3.5 FLASHING

Flash penetrations through membrane. Ensure that where reinforcing bars penetrate a waterproofing membrane, each of those penetrations be sealed with the appropriate sealant or mastic flashing component. Embed elastomeric membrane in a heavy coat of adhesive, except for self-adhering membrane. Continuous metal reglets shall be installed, horizontally on footing and vertically on intersecting and connecting walls, and as specified in Section 07 60 00 FLASHING AND SHEET METAL. Metal reglets shall receive exposed edges of membrane waterproofing. Secure membrane into reglets by lead wedges and fill with cement as recommended by manufacturer of waterproofing materials. Counterflash upper edge of membrane waterproofing and protective covering as specified in Section 07 60 00 FLASHING AND SHEET METAL.

3.6 FIELD QUALITY CONTROL

Notify the Contracting Officer one day prior to date of performing tests. Before concealment, cover elastomeric waterproofing on horizontal surfaces over finished spaces with 75 mm (3 inches) of ponded water for 24 hours. Do not add water after start of 24 hour period. Carefully measure water level at beginning and end of 24 hour period. If water level falls, remove water and inspect waterproofing membrane. Make repairs or replacement as directed, and repeat test. After test has passed, submit test report to Contracting Officer stating that elastomeric waterproofing has passed. Include date and time of failed tests, repairs made after failed tests, and date and time of test that passed. Contractor's Quality Control Manager shall verify and sign test report. Do not proceed with work that conceals membrane waterproofing before receiving approval and acceptance of test report submittal from Contracting Officer.

3.7 PROTECTIVE COVERING

After installation has been inspected and approved by the Contracting Officer, apply a protective covering to the membrane waterproofing prior to backfilling. Protect vertical membrane waterproofing with a 13 mm (1/2 inch) minimum thickness of asphalt plank; 13 mm (1/2 inch) minimum thickness of fiberboard; or 3 mm (1/8 inch) minimum thickness of compatible water-resistant bitumen type protection board with edges abutting adjacent edges and exposed surfaces covered by a taping system recommended by manufacturer of protection board. Cover horizontal membrane waterproofing with similar protection board and Portland cement mortar not less than 20 mm (3/4 inch) thick; place uniformly and allow to set before installing subsequent construction.

-- End of Section --

SECTION 07 14 00

FLUID-APPLIED WATERPROOFING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C578	(2011be1) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C836/C836M	(2011a) High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use With Separate Wearing Course
ASTM D1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fluid-applied membrane
Elastomeric sheet
Flexible foam-backed elastomeric sheetBond breaker

SD-11 Closeout Submittals

Warranty

Information Card
Instructions To Government Personnel

1.3 PRE-WATERPROOFING CONFERENCE

Prior to starting application of waterproofing system, arrange and attend a pre-waterproofing conference to ensure a clear understanding of drawings and specifications. Give the Contracting Officer 7 days advance written notice of the time and place of meeting. Ensure that the mechanical and electrical subcontractor, flashing and sheetmetal subcontractor, and other trades that may perform other types of work on or over the membrane after installation, attend this conference.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver waterproofing materials in manufacturer's original, unopened containers, with labels intact and legible. Containers of materials covered by a referenced specification number shall bear the specification number, type, and class of the contents. Deliver materials in sufficient quantity to continue work without interruption. Store and protect materials in accordance with manufacturer's instructions, and use within their indicated shelf life. When hazardous materials are involved, adhere to special precautions of the manufacturer, unless precautions conflict with local, state, and federal regulations. Promptly remove from the site materials or incomplete work adversely affected by exposure to moisture or freezing. Store materials on pallets and cover from top to bottom with canvas tarpaulins.

1.5 ENVIRONMENTAL CONDITIONS

Apply materials when ambient temperature is 4 degrees C (40 degrees F) or above for a period of 24 hours prior to the application and when there is no ice, frost, surface moisture, or visible dampness on the substrate surface. Apply materials when air temperature is expected to remain above 4 degrees C (40 degrees F) during the cure period recommended by the manufacturer. Moisture test for substrate is specified under paragraph entitled "Moisture Test." Work may be performed within heated enclosures, provided the surface temperature of the substrate is maintained at a minimum of 4 degrees C (40 degrees F) for 24 hours prior to the application of the waterproofing, and remains above that temperature during the cure period recommended by the manufacturer.

1.6 WARRANTY

Provide roof system material and workmanship warranties meeting specified requirements. Provide revisions or amendment to standard membrane manufacturer warranty to comply with the specified requirements. Minimum manufacturer warranty shall have no dollar limit, cover full system water-tightness, and shall have a minimum duration of 20 years.

1.6.1 Roof Membrane Manufacturer Warranty

Furnish the roof membrane manufacturer's 20-year no dollar limit roof system materials and installation workmanship warranty, including flashing, insulation, and accessories necessary for a watertight roof system construction. Write the warranty directly to the Government commencing at time of Government's acceptance of the roof work. Provide the following statements for such warranty:

a. If within the warranty period the roof system, as installed for its intended use in the normal climatic and environmental conditions of the facility, becomes non-watertight, shows evidence of moisture intrusion within the assembly, blisters, splits, tears, cracks, delaminates, separates at the seams, or shows evidence of excessive weathering due to defective materials or installation workmanship, the repair or replacement of the defective and damaged materials of the roof system assembly and correction of defective workmanship are the responsibility of the roof membrane manufacturer. All cost associated with the repair or replacement work are the responsibility of the roof membrane manufacturer.

b. The warranty must remain in full force and effect, including emergency temporary repairs performed by others, when the manufacturer or his approved applicator fails to perform the repairs within 72 hours of notification.

1.6.2 Roofing System Installer Warranty

The roof system installer must warrant for a minimum period of two years that the roof system, as installed, is free from defects in installation workmanship, to include the roof membrane, flashing, insulation, accessories, attachments, and sheet metal installation integral to a complete watertight roof system assembly. Write the warranty directly to the Government. The roof system installer is responsible for correction of defective workmanship and replacement of damaged or affected materials. The roof system installer is responsible for all costs associated with the repair or replacement work.

1.6.3 Continuance of Warranty

Approve repair or replacement work that becomes necessary within the warranty period and accomplished in a manner so as to restore the integrity of the roof system assembly and validity of the roof membrane manufacturer warranty for the remainder of the manufacturer warranty period.

PART 2 PRODUCTS

2.1 FLUID-APPLIED MEMBRANE

ASTM C836/C836M.

2.2 MEMBRANE PRIMER

As recommended by the fluid-applied membrane manufacturer unless specifically prohibited by the manufacturer of the fluid-applied membrane.

2.3 SEALANT

As specified in Section 07 92 00 JOINT SEALANTS.

2.4 SEALANT PRIMER

As specified in Section 07 92 00 JOINT SEALANTS.

2.5 BACKING MATERIAL

Pre-molded, closed-cell, polyethylene, or polyurethane foam rod having a diameter 25 percent larger than joint width before being compressed into joint. Provide bond breaker of polyethylene film or other suitable material between backing material and sealant.

2.6 JOINT FILLER

As specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, ASTM D1751 or ASTM D1752.

2.7 BOND BREAKER

As recommended by the fluid-applied membrane manufacturer. Bond breaker shall not interfere with the curing process or other performance properties of the fluid-applied membrane.

Submit material description and physical properties, application details, and recommendations regarding shelf life, application procedures, and precautions on flammability and toxicity.

2.8 ELASTOMERIC SHEET

Preformed; as recommended by the fluid-applied membrane manufacturer. Bond strength between the fluid-applied membrane and the preformed elastomeric sheet shall be a minimum of 7 kPa (one psi) when tested in accordance with ASTM C836/C836M.

2.9 ELASTOMERIC SHEET ADHESIVE

As recommended by the elastomeric sheet manufacturer.

2.10 FLEXIBLE FOAM-BACKED ELASTOMERIC SHEET

Flexible foam-backed elastomeric sheet for protection over preformed elastomeric sheet at expansion joints shall be 13 mm (1/2 inch) thick, minimum, closed cell foam conforming to ASTM D1056, Type 2, Class B, Grades 2 or 3, factory-bonded to 2 mm (1/16 inch) thick, minimum, preformed elastomeric sheet.

2.11 PROTECTION BOARD

Pre-molded bitumen composition board, 3 mm (1/8 inch) minimum thickness or other composition board compatible with the fluid-applied membrane.

2.12 DRAINAGE COURSE AGGREGATE

ASTM C33/C33M, size No. 8.

2.13 INSULATION

Polystyrene foam conforming to ASTM C578, Class IV, thickness as required by indicated R-value.

2.14 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Coordinate work with that of other trades to ensure that components to be incorporated into the waterproofing system are available when needed. Inspect and approve surfaces immediately before application of waterproofing materials. Remove laitance, loose aggregate, sharp projections, grease, oil, dirt, curing compounds, and other contaminants which could adversely affect the complete bonding of the fluid-applied membrane to the concrete surface.

3.1.1 Flashings

Make penetrations through sleeves in concrete slab watertight before application of waterproofing. After flashing is completed, cover elastomeric sheet with fluid-applied waterproofing during waterproofing application.

3.1.1.1 Drains

Make drain flanges flush with surface of structural slab. Apply a full elastomeric sheet around the drain, with edges fully adhered to drain flange and to structural slab. Do not adhere elastomeric sheet over joint between drain and concrete slab. Do not plug drainage or weep holes. Cover elastomeric sheet with fluid-applied waterproofing during waterproofing application. Lap elastomeric sheet a minimum of 100 mm (4 inches) onto concrete slab.

3.1.1.2 Penetrations and Projections

Flash penetrations and projections through structural slab with an elastomeric sheet adhered to the concrete slab and the penetration. Leave elastomeric sheet unadhered for 25 mm (one inch) over joint between penetration and concrete slab. Adhere elastomeric sheet a minimum of 100 mm (4 inches) onto horizontal deck.

3.1.1.3 Walls and Vertical Surfaces

Flash wall intersections which are not of monolithic pour or constructed with reinforced concrete joints with an elastomeric sheet adhered to both vertical wall surfaces and concrete slab. Flash intersections which are monolithically poured or constructed with reinforced concrete joints with either an elastomeric sheet or a vertical grade of fluid-applied waterproofing adhered to vertical wall surfaces and concrete slab. Leave sheet unadhered for a distance of 25 mm (one inch) from the corner on both vertical and horizontal surfaces.

3.1.2 Cracks and Joints

Prepare visible cracks and joints in substrate to receive fluid-applied waterproofing membrane by placing a bond breaker and an elastomeric slip sheet between membrane and substrate. Cracks that show movement shall receive a 50 mm (2 inch) bond breaker followed by an elastomeric sheet adhered to the deck. Nonmoving cracks shall be double coated with fluid-applied waterproofing.

3.1.3 Priming

Prime surfaces to receive fluid-applied waterproofing membrane. Apply primer as required by membrane manufacturer's printed instructions.

3.2 SPECIAL PRECAUTIONS

Protect waterproofing materials during transport and application. Do not dilute primers and other materials, unless specifically recommended by materials manufacturer. Keep containers closed except when removing contents. Do not mix remains of unlike materials. Thoroughly remove residual materials before using application equipment for mixing and transporting materials. Do not permit equipment on the project site that has residue of materials used on previous projects. Use cleaners only for cleaning, not for thinning primers or membrane materials. Ensure that workers and others who walk on cured membrane wear clean, soft-soled shoes to avoid damaging the waterproofing materials.

3.3 APPLICATION

Over primed surfaces, provide a uniform, wet, monolithic coating of fluid-applied membrane, 1.5 mm (60 mils) thick, plus or minus 0.125 mm (5 mils) by following manufacturer's printed instructions. Apply material by trowel, squeegee, roller, brush, spray apparatus, or other method recommended by membrane manufacturer. Check wet film thickness as specified in paragraph entitled "Film Thickness" and adjust application rate as necessary to provide a uniform coating of the thickness specified. Where possible, mark off surface to be coated in equal units to facilitate proper coverage. At expansion joints, control joints, prepared cracks, flashing, and terminations, carry membrane over preformed elastomeric sheet in a uniform 1.5 mm (60 mil) thick, plus or minus 0.125 mm (5 mils), wet thickness to provide a monolithic coating. If membrane cures before next application, wipe previously applied membrane with a solvent to remove dirt and dust that could inhibit adhesion of overlapping membrane coat. Use solvent recommended by the membrane manufacturer, as approved.

3.3.1 Work Sequence

Perform work so that protection board is installed prior to using the waterproofed surface. Do not permanently install protection board until the membrane has passed the flood test specified under paragraph entitled "Flood Test." Move material storage areas as work progresses to prevent abuse of membrane and overloading of structural deck.

3.3.2 Protection Board

Protect fluid-applied membrane by placing protection board over membrane at a time recommended by the membrane manufacturer. Protect membrane application when protection board is not placed immediately. Butt protection boards together and do not overlap.

3.3.3 Drainage Course

Place drainage course where shown after flood tests are completed and concrete protection slab or wearing course is ready to be installed.

3.3.4 Insulation

Place insulation of thickness indicated, on top of drainage course just prior to placement of concrete protection slab.

3.4 FIELD QUALITY CONTROL

3.4.1 Moisture Test

Prior to application of fluid-applied waterproofing, measure moisture content of substrate with a moisture meter in the presence of the Contracting Officer. An acceptable device is the Delmhorst Moisture Meter, Model BD7/2E/CS, Type 21 E. Similar meters by other manufacturers, which are suitable for the purpose, may be used as approved by the Contracting Officer. Do not begin application until meter reading indicates "dry" range.

3.4.2 Film Thickness

Measure wet film thickness every 10 square meters (100 square feet) during application by placing flat metal plates on the substrate or using a mil-thickness gage especially manufactured for the purpose.

3.4.3 Flood Test

After application and curing is complete, plug drains and fill waterproofed area with water to a depth of 50 mm (2 inches). A minimum 48 hour cure time, or longer cure time if recommended by the membrane manufacturer, shall be required prior to flood testing. Allow water to stand 24 hours. Test water-tightness by measuring water level at beginning and end of the 24 hour period. If water level falls, drain water, allow installation to dry, and inspect. Make repairs or replace as required and repeat the test. Work shall not proceed before approval of repairs or replacement.

3.5 INSTRUCTIONS TO GOVERNMENT PERSONNEL

Provide verbal and one hard copy & one digital copy (.pdf - text searchable) of instructions on proper maintenance procedures to designated Government personnel. Furnish instructions by a competent representative of the roof membrane manufacturer and include a minimum of 4 hours on maintenance and emergency repair of the membrane. Include a demonstration of membrane repair, and give sources of required special tools. Furnish information on safety requirements during maintenance and emergency repair operations. Include one hard copy & one digital copy (.pdf - text searchable) of Material Safety Data Sheets for maintenance/repair materials.

3.6 INFORMATION CARD

For each roof application, furnish a one hard copy & one digital copy (.pdf - text searchable) of information card for facility records and a card laminated in plastic and framed for interior display at roof access point, or a photoengraved 1 mm (0.032 inch) thick aluminum card for exterior display. Identify facility name and number; location; contract number; approximate roof area; detailed roof system description, including deck type, membrane, number of plies, method of application, manufacturer, insulation and cover board system and thickness; presence of tapered insulation for primary drainage, presence of vapor retarder; date of completion; installing contractor identification and contract information; membrane manufacturer warranty expiration, warranty reference number, and contact information. Install card at roof top or access location as directed by the Contracting Officer and provide a paper copy to the Contracting Officer.

FORM 1
FLUID-APPLIED WATERPROOFING SYSTEM COMPONENTS
1. Contract Number
2. Date Work Completed
3. Project Specification Designation
4. Substrate Material
5. Slope of Substrate
6. Drains Type/Manufacturer
7. Waterproofing
a. Membrane
b. Sealant
c. Elastomeric Sheet
d. Materials Manufacturer(s)
8. Protection Board
a. Type
b. Thickness
c. Manufacturer's Name
9. Drainage Course Material Graduation
10. Insulation
a. Type
b. Thickness
c. Manufacturer's Name
11. Protection Slab
a. Material
b. Thickness
c. Support

FORM 1	
FLUID-APPLIED WATERPROOFING SYSTEM COMPONENTS	
d. Joint System	
12. Wearing Course	
a. Type	
b. Slope	
c. Joint System	
d. Sealant/Gasket Type	
13. Wearing Surface Type	
Manufacturer's Name	
14. Warranty	
a. Manufacturer warranty expiration	
b. Warranty reference number	
15. Statement of Compliance or Exception	
Contractor's Signature	Date Signed
Inspector's Signature	Date Signed

-- End of Section --

SECTION 07 21 13

BOARD AND BLOCK INSULATION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C1289	(2012) Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
ASTM C165	(2007) Standard Test Method for Measuring Compressive Properties of Thermal Insulations
ASTM C203	(2005a; R 2012) Breaking Load and Flexural Properties of Block-Type Thermal Insulation
ASTM C272/C272M	(2012) Standard Test Method for Water Absorption of Core Materials for Sandwich Constructions
ASTM C552	(2014) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C578	(2011be1) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C591	(2012a) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C612	(2014) Mineral Fiber Block and Board Thermal Insulation
ASTM C930	(2005) Potential Health and Safety Concerns Associated with Thermal Insulation Materials and Accessories
ASTM D1621	(2010) Compressive Properties of Rigid Cellular Plastics
ASTM D3833/D3833M	(1996; R 2011) Water Vapor Transmission of Pressure-Sensitive Tapes

ASTM D4397	(2010) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM E136	(2011) Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C
ASTM E154	(2008a) Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2013) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 31	(2011) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2015) National Fuel Gas Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.134	Respiratory Protection

KOREAN INDUSTRIAL STANDARDS (KS)

KS M 3808	(2011) Foam Polystyrene Thermal Insulation Material
KS M 3809	(2011) Thermal Insulation Material Made of Rigid Urethane Foam

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Block or board insulation
Vapor retarder
Pressure sensitive tape

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery

Deliver materials to the site in original sealed wrapping bearing manufacturer's name and brand designation, specification number, type, grade, R-value, and class. Store and handle to protect from damage. Do not allow insulation materials to become wet, soiled, crushed, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storing, and protecting of materials before and during installation.

1.3.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling.

1.4 SAFETY PRECAUTIONS

1.4.1 Respirators

Provide installers with dust/mist respirators, training in their use, and protective clothing, all approved by National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA) in accordance with 29 CFR 1910.134.

1.4.2 Other Safety Considerations

Consider safety concerns and measures as outlined in ASTM C930.

PART 2 PRODUCTS

2.1 BLOCK OR BOARD INSULATION

Provide only thermal insulating materials recommended by manufacturer for type of application indicated. Provide board or block thermal insulation conforming to the following standards and the physical properties listed below:

a. Cellular Glass: ASTM C552

b. Extruded Preformed Cellular Polystyrene: ASTM C578 or KS M 3808

c. Mineral Fiber Block and Board: ASTM C612

d. Unfaced Preformed Rigid Polyurethane and Polyisocyanurate Board: ASTM C591

e. Faced Rigid Cellular Polyisocyanurate and Polyurethane Insulation: ASTM C1289 or KS M 3809, Type I Class 1 or Type II Class 1

   1. Type I Aluminum Foil on both major surfaces. Class 1 - Non-reinforced core foam.

   2. Type II Fibrous felt or glass fiber mat membrane on both major surfaces of the core foam.

3. Type III Perlite insulation board on one major surface of the core foam and a fibrous felt or glass fiber mat membrane on the other major surface of the core foam.

4. Type IV Cellulosic fiber insulating board on the one major surface of the core foam and fibrous felt or glass fiber mat membrane on the other major surface of the core foam.

5. Type V Oriented strand board or water-board on one major surface of the core foam and fibrous felt or glass fiber mat membrane or aluminum foil on the other major surface of the core foam.

6. Type VI Perlite insulation board on both major surfaces of the core foam.

2.1.1 Thermal Resistance

As indicated.

2.1.2 Fire Protection Requirement

a. Flame spread index of 100 or less when tested in accordance with ASTM E84.

b. Smoke developed index of 200 or less when tested in accordance with ASTM E84.

2.1.3 Other Material Properties

Provide thermal insulating materials with the following properties:

a. Rigid cellular plastics: Compressive Resistance at Yield: Not less than 170 kPa (10 psi) when measured according to ASTM D1621.

b. Mineral fiber board: Compressive strength: Minimum load required to produce a reduction in thickness of 10 percent, 120 kg/m^2 (25 lbf/sf) when tested according to ASTM C165.

b. Flexural strength: Not less than 275 kPa (25 psi) when measured according to ASTM C203.

c. Water Vapor Permeance: Not more than 6.3 by 10-8 g/Pa.s.m2 (1.1 Perms) or less when measured according to ASTM E96/E96M, desiccant method, in the thickness required to provide the specified thermal resistance, including facings, if any.

d. Water Absorption: Not more than 2 percent by total immersion, by volume, when measured according to ASTM C272/C272M.

e. Water Adsorption: Not more than 1 percent by volume when measured in accordance with paragraph 14 of ASTM C553.

2.1.4 Pre-molded Concrete Masonry Insert

ASTM C578. Install inserts in concrete masonry units at the masonry unit manufacturing plant. Provide insert with thickness not less than 32 mm (1 1/4 inches).

2.1.5 Recycled Materials

Provide thermal insulation containing recycled materials to the extent practicable, provided that the material meets all other requirements of this section. The minimum required recycled material contents (by weight, not volume) are:

Polyisocyanurate/Polyurethane:	9 percent
Phenolic Rigid Foam:	5 percent
Perlite Board:	23 percent

2.1.6 Prohibited Materials

Do not provide materials containing more than one percent of asbestos.

2.2 VAPOR RETARDER AND DAMPPROOFING

2.2.1 Vapor Retarder in Frame Walls and Roofs

.1524 mm (6 mil) thick polyethylene sheeting conforming to ASTM D4397 and having a water vapor permeance of 5.72 by 10-8g/Pa.s.m2 (one perm) or less when tested in accordance with ASTM E96/E96M.

2.2.2 Dampproofing for Masonry Cavity Walls

Bituminous material is specified in Section 07 11 13 BITUMINOUS DAMPPROOFING. Parging material is specified in Section 04 20 00 MASONRY.

2.2.3 Vapor Retarder under Floor Slab

a. Water vapor permeance: 1.14 by 10-8 g/Pa.s.m2 (0.2 Perm) or less when tested in accordance with ASTM E96/E96M.

b. Puncture resistance: Maximum load no less than 18 kilograms (40 pounds) when tested according to ASTM E154.

2.3 PRESSURE SENSITIVE TAPE

As recommended by manufacturer of vapor retarder and having a water vapor permeance rating of 5.72 by 10-8 g/Pa.s.m2 (one perm) or less when tested in accordance with ASTM D3833/D3833M.

2.4 PROTECTION BOARD OR COATING

As recommended by insulation manufacturer.

2.5 ACCESSORIES

2.5.1 Adhesive

As recommended by insulation manufacturer.

2.5.2 Mechanical Fasteners

Corrosion resistant fasteners as recommended by the insulation manufacturer.

2.6 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

Before installing insulation, ensure that all areas that will be in contact with the insulation are dry and free of projections which could cause voids, compressed insulation, or punctured vapor retarders. If installing perimeter or under slab insulation, check that the fill is flat, smooth, dry, and well tamped. If moisture or other conditions are found that do not allow the proper installation of the insulation, do not proceed but notify the Contracting Officer of such conditions.

3.2 PREPARATION

3.2.1 Blocking Around Heat Producing Devices

Unless using insulation board that passes ASTM E136 in addition to the requirements in Part 2, install non-combustible blocking around heat producing devices to provide the following clearances:

a. Recessed lighting fixtures, including wiring compartments, ballasts, and other heat producing devices, unless certified for installation surrounded by insulation: 75 mm (3 inches) from outside face of fixtures and devices or as required by NFPA 70and, if insulation is to be placed above fixture or device, 600 mm (24 inches) above fixture.

b. Masonry chimneys or masonry enclosing a flue: 50 mm (2 inches) from outside face of masonry. Masonry chimneys for medium and high heat operating appliances: Minimum clearances required by NFPA 211.

c. Vents and vent connectors used for venting products of combustion, flues, and chimneys other than masonry chimneys: minimum clearances as required by NFPA 211.

d. Gas Fired Appliances: Clearances as required in NFPA 54.

e. Oil Fired Appliances: Clearances as required in NFPA 31.

Blocking is not required if chimneys or flues are certified by the Manufacturer for use in contact with insulating materials.

3.3 INSTALLATION

3.3.1 Insulation Board

Install and handle insulation in accordance with the manufacturer's installation instructions. Keep material dry and free of extraneous materials. Observe safe work practices.

3.3.2 Electrical Wiring

Do not install insulation in a manner that would sandwich electrical wiring between two layers of insulation.

3.3.3 Cold Climate Requirement

Place insulation to the outside of pipes.

3.3.4 Continuity of Insulation

Butt tightly against adjoining boards, studs, rafters, joists, sill plates, headers and obstructions. Provide continuity and integrity of insulation at corners, wall to ceiling joint, roof, and floor. Avoid creating any thermal bridges or voids.

3.4 INSTALLATION ON WALLS

3.4.1 Installation using Furring Strips

Install insulation between members as recommended by insulation manufacturer.

3.4.2 Installation on Masonry Walls

Apply board directly to masonry with adhesive or fasteners as recommended by the insulation manufacturer. Fit between obstructions without impaling board on ties or anchors. Apply in parallel courses with joints breaking midway over course below. Put ends in moderate contact with adjoining insulation without forcing. Cut and shape as required to fit around wall penetrations, projections or openings to accommodate conduit or other services. Seal around cut-outs with sealant. Install board in wall cavities so that it leaves at least a nominal 25 mm (one inch) free air space outside of the insulation to allow for cavity drainage.

Insert premolded or board insulation into masonry unit hollow cores as recommended by the insulation manufacturer.

3.4.3 Adhesive Attachment to Concrete and Masonry Walls

Apply adhesive to wall and completely cover wall with insulation.

a. Full back bed method or

b. Spot method: Provide at least six spots having diameter of approximately 100 mm (4 inches), located at each corner and mid-points of each of the longer sides of each board.

c. As recommended by the insulation manufacturer.

d. Use only full back method for pieces of 0.1 square meter (one square foot) or less.

e. Butt all edges of insulation and seal edges with tape.

3.4.4 Mechanical Attachment on Concrete and Masonry Walls

Cut insulation to cover walls. Apply adhesive to wall and set clip or other mechanical fastener in adhesive as recommended by manufacturer.

After curing of adhesive, install insulation over fasteners, bend split prongs flush with insulation. Butt all edges of insulation and seal with tape.

3.4.5 Protection Board or Coating

Install protection board or coating in accordance with manufacturer's instructions. Install protection over all exterior exposed insulation board and down to 300 mm (1 foot) below grade.

3.5 INSTALLATION ON UNDERSIDE OF CONCRETE FLOOR SLAB

3.5.1 Mechanically Fastened Systems

Size insulation to cover underside of slab. Apply adhesive to slab and set fasteners in adhesive as recommended by manufacturer. After curing of adhesive, install insulation over fasteners, bend split prongs flush with insulation. Butt all edges of insulation and seal with tape.

3.5.2 Adhesively Bonded Systems

Apply adhesive to underside of the and completely cover wall with insulation.

a. Full back bed method or

b. Spot method: Provide at least six spots having a diameter of approximately 100 mm (4 inches), located at each corner and mid-point of each of the longer sides.

c. As recommended by insulation manufacturer.

d. Use full back method for insulation pieces 0.1 square meter (one square foot) or less.

e. Butt all edges of insulation and seal with tape.

3.6 PERIMETER AND UNDER SLAB INSULATION

Install perimeter thermal insulation where heated spaces are adjacent to exterior walls or slab edges in slab-on-grade or floating-slab construction.

3.6.1 Manufacturer's Instructions

Install, attach, tape edges, and provide vapor retarder and other requirements such as protection against vermin, insects, and damage during construction as recommended in manufacturer's instructions.

3.6.2 Insulation on Vertical Surfaces

Install thermal insulation as indicated. Fasten insulation with adhesive or mechanical fasteners.

3.6.3 Insulation Under Slab

Provide insulation horizontally under entire slab on grade as indicated. Install insulation on top of vapor retarder and turn retarder up over the outside edge of insulation to top of slab.

3.6.4 Protection of Insulation

Protect insulation on vertical surfaces from damage during construction and back filling by application of protection board or coating. Do not leave installed vertical insulation unprotected overnight. Install protection over entire exposed exterior insulation board.

3.7 VAPOR RETARDER

Apply a continuous vapor retarder as indicated. Overlap all joints at least 150 mm (6 inches) and seal with pressure sensitive tape. Seal at sill, header, windows, doors and utility penetrations. Repair punctures or tears with pressure sensitive tape.

3.8 ACCESS PANELS AND DOORS

Affix insulation to all access panels greater than 0.1 square meter (one square foot) and all access doors in insulated floors and ceilings. Use insulation with same R-Value as that for floor or ceiling.

-- End of Section --

SECTION 07 21 16

MINERAL FIBER BLANKET INSULATION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C665	(2011) Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
ASTM C930	(2005) Potential Health and Safety Concerns Associated with Thermal Insulation Materials and Accessories
ASTM D3575	(2008) Flexible Cellular Materials Made From Olefin Polymers
ASTM D3833/D3833M	(1996; R 2011) Water Vapor Transmission of Pressure-Sensitive Tapes
ASTM D4397	(2010) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM E136	(2011) Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS L 9102	(2011) Artificial Mineral Fiber Thermal Insulation Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2013) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 31	(2011) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2015) National Fuel Gas Code

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.134	Respiratory Protection

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Blanket insulation
Sill sealer insulation
Vapor retarder
Pressure sensitive tape

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery

Deliver materials to site in original sealed wrapping bearing manufacturer's name and brand designation, specification number, type, grade, R-value, and class. Store and handle to protect from damage. Do not allow insulation materials to become wet, soiled, crushed, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storing, and protecting of materials before and during installation.

1.3.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling.

1.4 SAFETY PRECAUTIONS

1.4.1 Respirators

Provide installers with dust/mist respirators, training in their use, and protective clothing, all approved by National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA) in accordance with 29 CFR 1910.134.

1.4.2 Smoking

Do not smoke during installation of blanket thermal insulation.

1.4.3 Other Safety Concerns

Consider other safety concerns and measures as outlined in ASTM C930.

PART 2 PRODUCTS

2.1 BLANKET INSULATION

ASTM C665 or KS L 9102, Type I, blankets without membrane coverings and II, blankets with non-reflecting coverings and III, blankets with reflective coverings; Class A, membrane-faced surface with a flame spread of 25 or less, except a flame spread rating of 25 or less and a smoke developed rating of 150 or less when tested in accordance with ASTM E84, unless otherwise indicated.

2.1.1 Thermal Resistance Value (R-VALUE)

As indicated

2.1.2 Recycled Materials

Provide Thermal Insulation containing recycled materials to the extent practicable, provided the material meets all other requirements of this section. The minimum required recycled materials content by weight are:

Rock Wool: 75 percent slag
Fiberglass: 20 to 25 percent glass cullet

2.1.3 Prohibited Materials

Do not provide asbestos-containing materials.

2.2 SILL SEALER INSULATION

Provide polyethylene foam sill sealer 190 millimeters (7.5 inches) in width, unless otherwise indicated, with the following characteristics:.

Physical Properties	Test Method	Measurement
Nominal Thickness	ASTM D3575	4.76 mm (3/16 inch)
Compressive Strength	ASTM D3575	8.27 kPa (1.2 psi)
- Vertical Direction	Suffix D	
Tensile Strength	ASTM D3575	220 kPa (32 psi)
	Suffix T	

2.3 BLOCKING

Wood, metal, unfaced mineral fiber blankets in accordance with ASTM C665 or KS L 9102, Type I, or other approved materials. Use only non-combustible materials meeting the requirements of ASTM E136 for blocking around chimneys and heat producing devices.

2.4 VAPOR RETARDER

a. 0.15 mm (6 mil) thick polyethylene sheeting conforming to ASTM D4397 and having a water vapor permeance of 5.72 by 10-8g/Pa.s.m2 (1 perm) or less when tested in accordance with ASTM E96/E96M.

2.5 PRESSURE SENSITIVE TAPE

As recommended by the vapor retarder manufacturer and having a water vapor permeance rating of 5.72 by 10-8 g/Pa.s.m2 (one perm) or less when tested in accordance with ASTM D3833/D3833M.

2.6 ACCESSORIES

2.6.1 Adhesive

As recommended by the insulation manufacturer.

2.6.2 Mechanical Fasteners

Corrosion resistant fasteners as recommended by the insulation manufacturer.

2.6.3 Wire Mesh

Corrosion resistant and as recommended by the insulation manufacturer.

2.7 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

Before installing insulation, ensure that areas that will be in contact with the insulation are dry and free of projections which could cause voids, compressed insulation, or punctured vapor retarders. If moisture or other conditions are found that do not allow the workmanlike installation of the insulation, do not proceed but notify Contracting Officer of such conditions.

3.2 PREPARATION

3.2.1 Blocking at Attic Vents and Access Doors

Prior to installation of insulation, install permanent blocking to prevent insulation from slipping over, clogging, or restricting air flow through soffit vents at eaves. Install permanent blocking around attic trap doors. Install permanent blocking to maintain accessibility to equipment or controls that require maintenance or adjustment.

3.2.2 Blocking Around Heat Producing Devices

Install non-combustible blocking around heat producing devices to provide the following clearances:

a. Recessed lighting fixtures, including wiring compartments, ballasts, and other heat producing devices, unless these are certified by the manufacturer for installation surrounded by insulation: 75 mm (3 inches) from outside face of fixtures and devices or as required by NFPA 70 and, if insulation is to be placed above fixture or device, 600 mm (24 inches) above fixture.

b. Masonry chimneys or masonry enclosing a flue: 50 mm (2 inches) from outside face of masonry. Masonry chimneys for medium and high heat operating appliances: Minimum clearances required by NFPA 211.

c. Vents and vent connectors used for venting the products of combustion, flues, and chimneys other than masonry chimneys: Minimum clearances as required by NFPA 211.

d. Gas Fired Appliances: Clearances as required in NFPA 54.

e. Oil Fired Appliances: Clearances as required in NFPA 31.

Blocking around flues and chimneys is not required when insulation blanket, including any attached vapor retarder, passed ASTM E136, in addition to meeting all other requirements stipulated in Part 2. Blocking is also not required if the chimneys are certified by the manufacturer for use in contact with insulating materials.

3.3 INSTALLATION

3.3.1 Insulation

Install and handle insulation in accordance with manufacturer's instructions. Keep material dry and free of extraneous materials. Ensure personal protective clothing and respiratory equipment is used as required. Observe safe work practices.

3.3.1.1 Electrical wiring

Do not install insulation in a manner that would sandwich electrical wiring between two layers of insulation.

3.3.1.2 Continuity of Insulation

Install blanket insulation to butt tightly against adjoining blankets and to studs, rafters, joists, sill plates, headers and any obstructions. Where insulation required is thicker than depth of joist, provide full width blankets to cover across top of joists. Provide continuity and integrity of insulation at corners, wall to ceiling joints, roof, and floor. Avoid creating thermal bridges.

3.3.1.3 Installation at Bridging and Cross Bracing

Insulate at bridging and cross bracing by splitting blanket vertically at center and packing one half into each opening. Butt insulation at bridging and cross bracing; fill in bridged area with loose or scrap insulation.

3.3.1.4 Cold Climate Requirement

Place insulation to the outside of pipes.

3.3.1.5 Insulation Blanket with Affixed Vapor Retarder

Locate vapor retarder as indicated. Do not install blankets with affixed vapor retarders unless so specified. Unless the insulation manufacturer's instructions specifically recommend not to staple the flanges of the vapor retarder facing, staple flanges of vapor retarder at 150 mm (6 inch) intervals flush with face or set in the side of truss, joist, or stud. Avoid gaps and bulges in insulation and "fish mouth" in vapor retarders. Overlap both flanges when using face method. Seal joints and edges of vapor retarder with pressure sensitive tape. Stuff pieces of insulation into small cracks between trusses, joists, studs and other framing, such as at attic access doors, door and window heads, jambs, and sills, band joists, and headers. Cover these insulated cracks with vapor retarder material and tape all joints with pressure sensitive tape to provide air and vapor tightness.

3.3.1.6 Insulation without Affixed Vapor Retarder

Provide snug friction fit to hold insulation in place. Stuff pieces of insulation into cracks between trusses, joists, studs and other framing, such as at attic access doors, door and window heads, jambs, and sills, band joists, and headers.

3.3.1.7 Sizing of Blankets

Provide only full width blankets when insulating between trusses, joists, or studs. Size width of blankets for a snug fit where trusses, joists or studs are irregularly spaced.

3.3.1.8 Special Requirements for Ceilings

Place insulation under electrical wiring occurring across joists. Pack insulation into narrowly spaced framing. Do not block flow of air through soffit vents. Attach insulation to attic door by adhesive or staples.

3.3.1.9 Installation of Sill Sealer

Size sill sealer insulation and place insulation over top of masonry or concrete perimeter walls or concrete perimeter floor slab on grade. Fasten sill plate over insulation.

3.3.1.10 Special Requirements for Floors

Hold insulation in place with corrosion resistant wire mesh, wire fasteners, or wire lacing.

3.3.1.11 Access Panels and Doors

Affix blanket insulation to access panels greater than one square foot and access doors in insulated floors and ceilings. Use insulation with same R-Value as that for floor or ceiling.

3.3.2 Installation of Separate Vapor Retarder

Apply continuous vapor retarder as indicated. Overlap joints at least 150 mm (6 inches) and seal with pressure sensitive tape. Seal at sill, header, windows, doors and utility penetrations. Repair punctures or tears with pressure sensitive tape.

-- End of Section --

SECTION 07 22 00

ROOF AND DECK INSULATION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C1177/C1177M	(2008) Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C1289	(2012) Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
ASTM C208	(2008a) Cellulosic Fiber Insulating Board
ASTM C552	(2014) Standard Specification for Cellular Glass Thermal Insulation
ASTM C578	(2011be1) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C726	(2011) Mineral Fiber Roof Insulation Board
ASTM C728	(2005; R 2010) Perlite Thermal Insulation Board
ASTM D2178	(2004) Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D312	(2000; R 2006) Standard Specification for Asphalt Used in Roofing
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D4263	(1983; R 2012) Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4586	(2007) Asphalt Roof Cement, Asbestos-Free
ASTM D4601	(2004) Asphalt-Coated Glass Fiber Base Sheet Used in Roofing
ASTM E84	(2014) Standard Test Method for Surface

	Burning Characteristics of Building Materials

FM GLOBAL (FM)

FM 4470	(2010) Single-Ply, Polymer-Modified Bitumen Sheet, Built-up Roof (BUR), and Liquid Applied Roof Assemblies for Use in Class 1 and Noncombustible Roof Deck Construction
FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/
FM P9513	(2002) Specialist Data Book Set for Roofing Contractors; contains 1-22 (2001), 1-28 (2002), 1-29 (2002), 1-28R/1-29R (1998), 1-30 (2000), 1-31 (2000), 1-32 (2000), 1-33 (2000), 1-34 (2001), 1-49 (2000), 1-52 (2000), 1-54 (2001)

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir	(2012) Building Materials Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3200	(2006) Fiberboards
KS F 4714	(2009) Water Repellent Heat Insulation Mad of Perlite
KS M 3809	(2011) Thermal Insulation Material Made of Rigid Urethane Foam

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Tapered roof insulation system; G

SD-03 Product Data

Insulation

SD-07 Certificates

Manufacturer's Certificate

1.3 TAPERED ROOF INSULATION SYSTEM

Show a complete description of the procedures for the installation of each phase of the system indicating the type of materials, thicknesses, identity codes, sequence of laying insulation, location of ridges and valleys, special methods for cutting and fitting of insulation, and special precautions. The drawings shall be based on field measurements.

1.4 MANUFACTURER'S CERTIFICATE

Submit certificate from the insulation manufacturer attesting that the installer has the proper qualifications for installing tapered roof insulation systems.

Certificate attesting that the expanded perlite or polyisocyanurate insulation contains recovered material and showing estimated percent of recovered material. Certificates of compliance for felt materials.

1.5 QUALITY ASSURANCE

1.5.1 Insulation on Decks

Roof insulation shall have a flame spread rating not greater than 75 and a smoke developed rating not greater than 150, exclusive of covering, when tested in accordance with ASTM E84. Insulation bearing the UL label and listed in the UL Bld Mat Dir as meeting the flame spread and smoke developed ratings will be accepted in lieu of copies of test reports. Compliance with flame spread and smoke developed ratings will not be required when insulation has been tested as part of a roof construction assembly of the type used for this project and the construction is listed as fire-classified in the UL Bld Mat Dir or listed as Class I roof deck construction in the FM APP GUIDE. Insulation tested as part of a roof construction assembly shall bear UL or FM labels attesting to the ratings specified herein.

1.5.2 Foam Board on Combustible or Steel Decks

Separate polyurethane or polystyrene insulation from a combustible or steel deck with a thermal barrier of glass mat gypsum roof board or roof insulation in accordance with the requirements of the UL Bld Mat Dir or the FM APP GUIDE.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Delivery

Deliver materials to site in manufacturer's unopened and undamaged standard commercial containers bearing the following legible information:

a. Name of manufacturer;

b. Brand designation;

c. Specification number, type, and class, as applicable, where materials are covered by a referenced specification; and

Deliver materials in sufficient quantity to allow continuity of the work.

1.6.2 Storage and Handling

Store and handle materials in a manner to protect from damage, exposure to open flame or other ignition sources, and from wetting, condensation or moisture absorption. Store in an enclosed building or trailer that provides a dry, adequately ventilated environment. Replace damaged material with new material.

1.7 ENVIRONMENTAL CONDITIONS

Do not install roof insulation during inclement weather or when air temperature is below 4 degrees C (40 degrees F) and interior humidity is 45 percent or greater, or when there is visible ice, frost, or moisture on the roof deck.

1.8 PROTECTION OF PROPERTY

1.8.1 Flame-Heated Equipment

Locate and use flame-heated equipment so as not to endanger the structure or other materials on the site or adjacent property. Do not place flame-heated equipment on the roof. Provide and maintain a fire extinguisher near each item of flame-heated equipment.

1.8.2 Protective Coverings

Install protective coverings at paving and building walls adjacent to hoist and kettles prior to starting the work. Lap protective coverings at least 150 mm (6 inches), secure them against wind, and vent them to prevent collection of moisture on the covered surfaces. Keep protective coverings in place for the duration of the work with asphalt products.

1.8.3 Special Protection

Provide special protection approved by the insulation manufacturer, or avoid heavy traffic on completed work when ambient temperature is above 27 degrees C (80 degrees F).

1.8.4 Drippage of Bitumen

Seal joints in and at edges of deck as necessary to prevent drippage of asphalt into building or down exterior walls.

PART 2 PRODUCTS

2.1 INSULATION

2.1.1 Insulation Types

Roof insulation shall be one or an assembly of a maximum of three of the following materials and compatible with attachment methods for the specified insulation and roof membrane:

a. Expanded Perlite Board: ASTM C728 or KS F 4714. Minimum 19 mm (3/4 inch) thick when both top and bottom surfaces will be in contact with asphalt.

b. Polyisocyanurate Board: ASTM C1289 or KS M 3809, except minimum compressive strength shall be 140 kPa (20 psi).

c. Composite Boards: ASTM C1289 (Polyisocyanurate-perlite).

d. Cellular Glass Boards: ASTM C552, Type IV.

e. Polystyrene Board: Shall be in accordance with ASTM C578, Type II, IV, or X.

2.1.2 Mineral-Fiber Insulation Board

ASTM C726 or KS F 3200.

2.1.3 Recovered Materials

Provide thermal insulation materials containing recycled materials to the extent practical. The required minimum recycled material content for the listed materials are:

Perlite Composition Board:	75 percent post-consumer paper
Polyisocyanurate/polyurethane:	9 percent recovered material
Wood Fiberboard:	25 percent recovered material
Cellular Glass Insulation:	75 percent recovered content
Structural Fiberboard:	100 percent recovered content
Fiberglass Insulation:	20-25 percent recovered content
Fiber (felt) or Fiber composite:	50-100 percent recovered content
Rubber:	12-100 percent recovered content
Plastic or Plastic/Rubber composite:	100 percent recovered content
Wood/Plastic Composite:	100 percent Total Recovered content

2.1.4 Insulation Thickness

As necessary to provide a thermal resistance (R value) as designed. Thickness shall be based on the "R" value for aged insulation. Insulation over steel decks shall satisfy both specified R value and minimum thickness for width of rib opening recommended in insulation manufacturer's published literature.

2.1.5 Tapered Roof Insulation

One layer of the tapered roof insulation assembly shall be factory tapered to a slope of not less than one in 24 (1/2 inch per foot), unless otherwise indicated. Provide starter and filler blocks as required to provide the total thickness of insulation necessary to meet the specified slope and thermal conductance. Mitered joints shall be factory fabricated and shall consist of two diagonally cut boards or one board shaped to provide the required slopes. Identify each piece of tapered insulation board by color or other identity coding system, allowing the identification of different sizes of tapered insulation board required to complete the roof insulation system.

2.2 PROTECTION BOARD

For use as a thermal barrier (underlayment), fire barrier (overlayment), or protection board for hot-mopped, torched-down, or adhesively-applied roofing membrane over roof insulation.

2.2.1 Glass Mat Gypsum Roof Board

ASTM C1177/C1177M, 0 Flame Spread and 0 Smoke Developed when tested in accordance with ASTM E84, 3450 kPa (500 psi), Class A, non-combustible, 13 mm (1/2 inch) thick, 1220 by 2440 mm (4 by 8 feet) board size, unless otherwise indicated.

2.2.2 High Density Wood Fiber

Provide improved impact resistance to roof covers, but is hydroscopic in nature. High density fiber board shall be Grade 2 in accordance with ASTM C208 with a transverse load of 53.4 N (12 lbf).

2.3 BITUMENS

2.3.1 Asphalt Primer

ASTM D41/D41M.

2.3.2 Asphalt

ASTM D312, Type III or IV. Asphalt flash point, finished blowing temperature, and equiviscous temperature (EVT) for mop and for mechanical spreader application shall be indicated on bills of lading or on individual containers.

2.3.3 Asphalt Roof Cement

ASTM D4586, Type I for horizontal surfaces and for surfaces sloped from 0 to 3 inches per foot, Type II for vertical and surfaces sloped more than 3 inches per foot.

2.4 SHEATHING PAPER FOR WOOD DECKS

Rosin-sized building paper or unsaturated felt weighing not less than 2.5 kilograms per 10 square meters (5 pounds per 100 square feet).

2.5 MOISTURE CONTROL

2.5.1 Vapor Retarder

2.5.1.1 Asphalt-Saturated Felt Base Sheet for Single Layer Application

ASTM D4601, weighing not less than 17.5 kilograms per 10 square meters (35 pounds per 100 square feet).

2.5.1.2 Asphalt-Coated Glass Felt

ASTM D2178.

2.5.2 Organic Roofing

ASTM D226/D226M, Type I.

2.6 FASTENERS

Flush-driven through flat round or hexagonal steel or plastic plates. Steel plates shall be zinc-coated, flat round not less than 35 mm (1 3/8 inch) diameter or hexagonal not less than 0.4 mm (28 gage). Plastic plates shall be high-density, molded thermoplastic with smooth top surface, reinforcing ribs and not less than 75 mm (3 inches) in diameter. Fastener head shall recess fully into the plastic plate after it is driven. Plates shall be formed to prevent dishing. Do not use bell-or cup-shaped plates. Fasteners shall conform to insulation manufacturer's recommendations except that holding power, when driven, shall be not less than 178 N (40 pounds) each in steel deck. Fasteners for steel or concrete decks shall conform to FM APP GUIDE for Class I roof deck construction, and shall be spaced to withstand an uplift pressure of 2.87 kPa (60 pounds per square foot).

2.6.1 Roofing Nails for Wood Decks

Barbed 3 mm (11 gage), zinc-coated nails with 11 to 16 mm (7/16 to 5/8 inch) diameter heads or annular ring shank, square head, one-piece composite nails. Nails shall be long enough to penetrate wood deck at least 16 mm (5/8 inch) but shall not protrude through underside of decking.

2.6.2 Fasteners for Plywood Decks

Annular ring shank, square head, one-piece composite nails long enough to penetrate into plywood decks approximately 13 mm (1/2 inch) but not protrude through underside of decking.

2.6.3 Fasteners for Steel Decks

Approved hardened penetrating fasteners or screws conforming to FM 4470 and listed in FM APP GUIDE for Class I roof deck construction. Quantity and placement to withstand a minimum uplift pressure of 2.87 kPa (60 psf) conforming to FM APP GUIDE.

2.6.4 Fasteners for Poured Concrete Decks

Approved hardened fasteners or screws to penetrate deck at least 25 mm (one inch) but not more than 38 mm (1-1/2 inches), conforming to FM 4470, and listed in FM APP GUIDE for Class I roof deck construction. Quantity and placement to withstand an uplift pressure of 2.87 kPa (60 psf) conforming to FM APP GUIDE.

2.7 WOOD NAILERS

Pressure-preservative-treated as specified in Section 06 10 00 ROUGH CARPENTRY.

2.8 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

3.1.1 Surface Inspection

Surfaces shall be clean, smooth, and dry. Surfaces receiving vapor retarder shall be free of projections which might puncture the vapor retarder. Check roof deck surfaces, including surfaces sloped to roof drains and outlets, for defects before starting work.

The Contractor shall inspect and approve the surfaces immediately before starting installation. Prior to installing vapor retarder, ventilating felt, or insulation, perform the following:

a. Examine wood decks to ascertain that deck boards have been properly nailed and that exposed nail heads have been set.

b. Examine steel decks to ensure that panels are properly secured to structural members and to each other and that surfaces of top flanges are flat or slightly convex.

c. Examine precast concrete decks to ensure that joints between precast units are properly grouted and leveled to provide suitable surfaces for installation of ventilating felt, vapor retarder, or insulation.

d. In the presence of the Contracting Officer perform the following surface-dryness test on concrete substrates:

    (1) Foaming: When poured on the deck, one pint of asphalt when heated in the range of 176 to 204 degrees C (350 to 400 degrees F), shall not foam upon contact.

    (2) Strippability: After asphalt used in the foaming test application has cooled to ambient temperatures, test coating for adherence. Should a portion of the sample be readily stripped clean from surface, do not consider surface to be dry and do not start application. Should rain occur during application, stop work and do not resume until surface has been tested by method above and found dry.

e. Prior to installing any roof system on a concrete deck, conduct a test per ASTM D4263. The deck is acceptable for roof system application when there is no visible moisture on underside of plastic sheet after 24 hours.

3.1.2 Surface Preparation

Correct defects and inaccuracies in roof deck surface to eliminate poor drainage and hollow or low spots and perform the following:

a. Install wood nailers the same thickness as insulation at eaves, edges, curbs, walls, and roof openings for securing cant strips, gravel stops, gutters, and flashing flanges.

b. Fill or cover cracks or knot holes larger than 13 mm (1/2 inch) in diameter in wood decks as necessary to form an unyielding surface.

c. Cover wood decks with a layer of rosin-sized building paper or unsaturated felt. Lap sides and ends not less than 75 mm (3 inches).

Nail sufficiently to prevent tearing or buckling during installation.

d. Cover steel decks with a layer of insulation board of sufficient thickness to span the width of a deck rib opening, and conforming to fire safety requirements. Secure with piercing or self-drilling, self-tapping fasteners of quantity and placement conforming to FM APP GUIDE. Insulation joints parallel to ribs of deck shall occur on solid bearing surfaces only, not over open ribs.

3.2 INSTALLATION OF VAPOR RETARDER

Install vapor retarder in direct contact with roof deck surface, ventilating felt or insulation. Vapor retarder shall consist of either two plies of No. 15 asphalt-saturated felt, two plies of asphalt-coated glass felt, or one layer of asphalt-saturated felt base sheet. Lay vapor retarder at right angles to direction of slope. Install first ply of felt or base sheet as specified herein for the specific deck. Apply second ply of 2-ply vapor retarder system using asphalt at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet), applied within plus or minus 15 degrees C (25 degrees F) of EVT. Do not heat asphalt above asphalt's FBT or 275 degrees C (525 degrees F), whichever is less. Use thermometers to check temperatures during heating and application. Side and end laps shall be completely sealed. Asphalt shall be visible beyond all edges of each ply as it is being installed. Plies shall be laid free of wrinkles, buckles, creases or fishmouths. Workers shall not walk on mopped surfaces when the asphalt is sticky. Press out air bubbles to obtain complete adhesion between surfaces. At walls, eaves and rakes, and other vertical surfaces, the vapor retarder organic felts shall be extended 225 mm (9 inches), or separate organic felt plies shall be extended 225 mm (9 inches), with not less than 225 mm (9 inches) on the substrate, and the extended portion turned back and mopped in over the top of the insulation. At roof penetrations other than walls, eaves and rakes, and vertical surfaces, the vapor retarder or separate plies shall be extended 225 mm (9 inches) to form a lap which shall later be folded back over the edge of the insulation. Asphalt roof cement shall be used under the vapor retarder for at least 225 mm (9 inches) from walls, eaves, rakes and other penetrations.

3.2.1 Vapor Retarder on Poured Concrete Decks

Solidly mop primed substrate with asphalt at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet) before installing vapor retarder. Lay first ply of 2 ply system with each sheet lapping 480 mm (19 inches) over the preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). For a vapor retarder consisting of one layer of asphalt base sheet, provide side and end laps not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). Cement base sheets together with a solid mopping of asphalt.

3.2.2 Vapor Retarder on Precast Concrete Decks

Solidly mop primed substrate with asphalt at rate of 10 to 18 kgs per square meters (20 to 35 lbs per 100 square feet) before installing vapor retarder. Lay first ply of 2 ply system with each sheet lapping 480 mm (19 inches) over preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). For vapor retarder consisting of one layer of asphalt base sheet, provide side and end laps not less than 100 mm (4 inches) and stagger laps a minimum of 300 mm (12 inches). Cement base sheets together with a solid mopping of asphalt.

3.2.3 Vapor Retarder on Wood Decks

Lay first ply of 2 ply system dry with each sheet lapping 50 mm (2 inches) over the preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). Nail felt at 150 mm (6 inch) intervals along side laps and install two rows of nails approximately 275 mm (11 inches) apart down longitudinal center of each sheet, with nails staggered at 450 mm (18 inches) O.C. For vapor retarder consisting of one layer of asphalt base sheet, lap each sheet 100 mm (4 inches) over the preceding sheet. Provide end laps not less than 100 mm (4 inches) and stagger laps a minimum of 300 mm (12 inches). Cement side and end laps together with solid mopping of asphalt or heavy coat of asphalt roof cement. Nail side laps at 150 mm (6 inch) intervals. Apply asphalt mopping at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet). Install two rows of nails approximately 275 mm (11 inches) apart down longitudinal center of each sheet, with nails staggered at 450 mm (18 inches) O.C.

3.2.4 Vapor Retarder on Steel Decks

Solidly mop the mechanically secured insulation surface with asphalt before installing vapor retarder. For a 2 ply vapor retarder, install each sheet lapping 480 mm (19 inches) over the preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger the laps a minimum of 300 mm (12 inches). Cement felts together with solid mopping of asphalt. Apply asphalt moppings at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet). For a vapor retarder consisting of one layer of asphalt base sheet, lap each sheet 100 mm (4 inches) over preceding sheet. Lap ends not less than 100 mm (4 inches), and stagger laps a minimum of 300 mm (12 inches). Cement base sheets together with solid mopping of asphalt.

3.2.5 Over Gypsum Insulating Concrete or Lightweight Insulating Concrete

One ply of venting inorganic base sheet shall be laid, without mopping, at right angle to the slope with 100 mm (4 inch) side laps and 150 mm (6 inch) end laps. Laps shall be bonded with hot asphalt. End laps shall be staggered. Base sheet shall be nailed 220 mm (9 inches) on centers at side laps and in 2 rows 270 mm (11 inches) apart down the center of the sheet with nails 450 mm (18 inches) on centers and staggered or attached to the concrete as determined by uplift requirements. The 2-ply vapor retarder shall then be applied over the base sheet as specified above.3.2.6 Over Concrete Decks and First Layer of Insulation on Steel Decks

The 2-ply vapor retarder shall be applied as specified above except that venting inorganic base sheet shall be deleted.

3.2.7 Over Structural Concrete on Non-Venting Support

One ply of venting inorganic base sheet with mopping holes shall be laid dry at right angle to the slope with 100 mm (4 inch) side laps and 150 mm (6 inch) end laps. The vapor retarder shall then be applied as specified.

3.3 INSULATION INSTALLATION

Apply insulation in two layers with staggered joints when total required thickness of insulation exceeds 13 mm (1/2 inch). Lay insulation so that continuous longitudinal joints are perpendicular to direction of roofing, and end joints of each course are staggered with those of adjoining courses. When using multiple layers of insulation, joints of each succeeding layer shall be parallel and offset in both directions with respect to layer below. Keep insulation 13 mm (1/2 inch) clear of vertical surfaces penetrating and projecting from roof surface.

3.3.1 Installation Using Asphalt

Firmly embed each layer in solid asphalt mopping; mop only sufficient area to provide complete embedment of one board at a time. Provide 10 to 18 kgs (20 to 35 lbs) of asphalt per 10 square meters (100 square feet) of roof deck for each layer of insulation. Apply asphalt when temperature is within plus or minus 15 degrees C (25 degrees F) of EVT. Do not heat asphalt above asphalt's FBT or 275 degrees C (525 degrees F), whichever is less, for longer than 4 consecutive hours. Use thermometers to check temperatures during heating and application.

3.3.2 Installation Using Asphalt on Steel Decks

Secure first layer of insulation and thermal barrier to deck with piercing or self-drilling, self-tapping fasteners. Engage fasteners by driving them through insulation into top flange of steel deck. Use driving method prescribed by fastener manufacturer. Insulation joints parallel to ribs of deck shall occur on solid bearing surfaces only, not over open ribs. Secure succeeding layers with solid asphalt moppings. Where insulation is applied over steel deck, long edge joints shall continuously bear on surfaces of the steel deck. Insulation which can be readily lifted after installation is not considered to be adequately secured. Insulation shall be applied so that all roof insulation applied each day is waterproofed the same day. Phased construction will not be permitted. Application of impermeable faced insulation shall be performed without damage to the facing.

3.3.3 Installation Using Only Mechanical Fasteners

Secure total thickness of insulation with penetrating type fasteners.

3.3.4 Special Precautions for Installation of Foam Insulation

3.3.4.1 Polyisocyanurate Insulation

Where polyisocyanurate foam board insulation is provided, install 13 mm (1/2 inch) thick wood fiberboard, glass mat gypsum roof board, or 19 mm (3/4 inch) thick expanded perlite board insulation over top surface of foam board insulation. Stagger joints of insulation with respect to foam board insulation below.

3.3.4.2 Polystyrene Insulation

a. Over top surface of non-composite polystyrene board, install 13 mm (1/2 inch) thick high density wood fiberboard, 19 mm (3/4 inch) thick expanded perlite board, glass mat gypsum roof board, or other overlayment approved by roofing sheet manufacturer. Tightly butt and stagger joints of field applied overlayment board at least 150 mm (6 inches) with respect to the polystyrene board below. Apply 150 mm (6 inch) wide glass fiber roofing tape centered over joints and edges of overlayment board.

b. Where composite boards consisting of polystyrene insulation are provided, apply 150 mm (6 inch) wide glass-fiber roofing tape centered over joints and edges of composite board. Apply joint strips as recommended by roofing sheet manufacturer.

3.3.5 Cant Strips

Where indicated, provide cant strips at intersections of roof with walls, parapets, and curbs extending above roof. Wood cant strips shall bear on and be anchored to wood blocking. Fit cant strips flush against vertical surfaces. Where possible, nail cant strips to adjoining surfaces. Where cant strips are installed against non-nailable materials, install in heavy mopping of asphalt or set in a heavy coating of asphalt roof cement.

3.3.6 Tapered Edge Strips

Where indicated, provide edge strips in the right angle formed by junction of roof and wood nailing strips that extend above level of roof. Install edge strips flush against vertical surfaces of wood nailing strips. Where possible, nail edge strips to adjoining surfaces. Where installed against non-nailable materials, install in heavy mopping of asphalt or set in heavy coating of asphalt roof cement.

3.4 PROTECTION

3.4.1 Protection of Applied Insulation

Completely cover each day's installation of insulation with the finished roofing in on same day. Do not permit phased construction. Protect open spaces between insulation and parapets or other walls and spaces at curbs, scuttles, and expansion joints, until permanent roofing and flashing are applied. Do not permit storing, walking, wheeling, or trucking directly on insulation or on roofed surfaces. Provide smooth, clean board or plank walkways, runways, and platforms near supports, as necessary, to distribute weight to conform to allowable live load limits of roof construction. Exposed edges of the insulation shall be protected by cutoffs at the end of each work day or whenever precipitation is imminent. Cutoffs shall be 2 layers of bituminous-saturated felt set in plastic bituminous cement or EPDM membrane set in roof cement. Fill all profile voids in cut-offs to prevent entrapping of moisture into the area below the membrane. Cutoffs shall be removed when work is resumed.

3.4.2 Damaged Work and Materials

Restore work and materials that become damaged during construction to original condition or replace with new materials.

3.5 INSPECTION

The Contractor shall establish and maintain an inspection procedure to assure compliance of the installed roof insulation with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Observation of environmental conditions; number and skill level of insulation workers; start and end time of work.

b. Verification of certification, listing or label compliance with FM P9513.

c. Verification of proper storage and handling of insulation and vapor retarder materials before, during, and after installation.

d. Inspection of vapor retarder application, including edge envelopes and mechanical fastening.

e. Inspection of mechanical fasteners; type, number, length, and spacing.

f. Coordination with other materials, cants, sleepers, and nailing strips.

g. Inspection of insulation joint orientation and laps between layers, joint width and bearing of edges of insulation on deck.

h. Installation of cutoffs and proper joining of work on subsequent days.

i. Continuation of complete roofing system installation to cover insulation installed same day.

-- End of Section --

SECTION 07 24 00

EXTERIOR INSULATION AND FINISH SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1177/C1177M	(2008) Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C1186	(2008) Standard Specification for Flat Non-Asbestos Fiber Cement Sheets
ASTM C1278/C1278M	(2007a) Standard Specification for Fiber-Reinforced Gypsum Panel
ASTM C1325	(2008b) Standard Specification for Non-Asbestos Fiber-Mat Reinforced Cement Substrate Sheets
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C473	(2010) Physical Testing of Gypsum Panel Products
ASTM C578	(2011be1) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C67	(2014) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C847	(2012) Standard Specification for Metal Lath
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D2247	(2011) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D3273	(2000; R 2005) Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber
ASTM D968	(2005; R 2010) Abrasion Resistance of

	Organic Coatings by Falling Abrasive
ASTM E136	(2011) Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C
ASTM E2098	(2000; R 2006) Determining Tensile Breaking Strength of Glass Fiber Reinforcing Mesh for Use in Class PB Exterior Insulation and Finish Systems (EIFS) after Exposure to a Sodium Hydroxide Solution
ASTM E2485	(2006) Standard Test Method for Freeze/Thaw Resistance of Exterior Insulation and Finish Systems (EIFS) and Water Resistive Barrier Coatings
ASTM E2486	(2006) Standard Test Method for Impact Resistance of Class PB and PI Exterior Insulation and Finish Systems (EIFS)
ASTM E330	(2002; R 2010) Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E331	(2000; R 2009) Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E695	(2003; R 2009) Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G153	(2013) Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

INTERNATIONAL CODE COUNCIL (ICC)

ICC UBC	(1997; Erratas Vol 1, 2 & 3 01/2001; Vol 1 & 2 03/2001; Vol 2 10/2001) Uniform Building Code

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4910	(2010) Sealants for Sealing and Glazing in Buildings
KS L 5201	(2013) Portland Cement
KS M 3808	(2011) Foam Polystyrene Thermal Insulation Material

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 268	(2012) Standard Test Method for Determining Ignitibility of Exterior Wall Assemblies Using a Radiant Heat Energy Source

1.2 SYSTEM DESCRIPTION AND REQUIREMENTS

The exterior insulation and finish system (EIFS) shall be a job-fabricated exterior wall covering consisting of sheathing, insulation board, reinforcing fabric, base coat, finish coat, adhesive and mechanical fasteners as applicable. The system components shall be compatible with each other and with the substrate as recommended or approved by, and the products of, a single manufacturer regularly engaged in furnishing Exterior Insulation and Finish Systems. All materials shall be installed by an applicator approved by the system manufacturer. EIFS shall be Class PB.

1.2.1 System Requirements and Tests

The system shall meet the performance requirements as verified by the tests listed below. Where a wall system of similar type, size, and design as specified for this project has been previously tested under the condition specified herein, the resulting test reports may be submitted in lieu of job specific tests.

1.2.1.1 Water Penetration

Test the system for water penetration by uniform static air pressure in accordance with ASTM E331. There shall be no penetration of water beyond the plane of the base coat/EPS board interface after 15 minutes at 300 Pa (6.4 psf), or 20 percent of positive design wind pressure, whichever is greater.

1.2.1.2 Wind Load

Test the system for wind load by uniform static air pressure in accordance with ASTM E330 (procedure A) to a minimum pressure of 7,180 Pa (150 psf). There shall be no permanent deformation, delamination, or other deterioration.

1.2.1.3 Full scale or intermediate scale fire test

Conduct wall fire test using apparatus, specimen, performance criteria, and procedure in accordance with ICC UBC, Chapter 26-4. The specimen shall include the complete system using 102 mm (4 inch) thick insulation board. At the option of the contractor, ICC UBC, Chapter 26-9, Intermediate-Scale Test may be substituted in lieu of the Full-Scale Multi- Story Fire test. The following requirements shall be met:

a. No vertical spread of flame within core of panel from one story to the next.

b. No flame spread over the exterior surface.

c. No vertical flame spread over the interior surface from one story to the next.

d. No significant lateral spread of flame from compartment of fire origin to adjacent spaces.

1.2.2 Component Requirements and Tests

The components of the system shall meet the performance requirements as verified by the tests listed below.

1.2.2.1 Surface Burning Characteristics

Conduct ASTM E84 test on samples consisting of base coat, reinforcing fabric, and finish coat. Cure for 28 days. The flame spread index shall be 25 or less and the smoke developed index shall be 450 or less.

1.2.2.2 Radiant Heat

The system shall be tested in accordance with NFPA 268 on both the minimum and maximum thickness of insulation intended for use with no ignition during the 20-minute period.

1.2.2.3 Impact Resistance

a. Class PB Systems: Hemispherical Head Test; 28 day cured specimen of PB EIFS in accordance with ASTM E2486. The test specimen shall exhibit no broken reinforcing fabric per ASTM E2486 at an impact of 10 - 17 J (90 - 150 inch pounds).

b. Impact Mass: Test 28 day cured specimen of PM EIFS in accordance with ASTM E695. The test specimen shall exhibit no cracking or denting after twelve impacts by 13.6 kg (30 lbs) lead shot mass from 150 to 1800 mm (6 inches to 6 feet drop heights in 150 mm (6 inch) intervals.

1.2.3 Sub-Component Requirements and Tests

Unless otherwise stated, the test specimen shall consist of reinforcing mesh, base coat, and finish coat applied in accordance with manufacturer's printed recommendations to the insulation board to be used on the building. For mildew resistance, only the finish coat is applied onto glass slides for testing. This specimen shall be suitably sized for the apparatus used and be allowed to cure for a minimum of 28 days prior to testing.

1.2.3.1 Abrasion Resistance

Test in accordance with ASTM D968, Method A. Test a minimum of two specimens. After testing, the specimens shall show only very slight smoothing, with no loss of film integrity after 500 liters (132 gallons) of sand.

1.2.3.2 Accelerated Weathering

Test in accordance with ASTM G153, Cycle 1. After 2000 hours specimens shall exhibit no visible cracking, flaking, peeling, blistering, yellowing, fading, or other such deterioration.

1.2.3.3 Mildew Resistance

Test in accordance with ASTM D3273. The specimen shall consist of the finish coat material, applied to clean 75 mm by 100 mm (3 inch by 4 inch) glass slides and shall be allowed to cure for 28 days. After 28 days of exposure, the specimen shall not show any growth.

1.2.3.4 Salt Spray Resistance

Test in accordance with ASTM B117. The specimen shall be a minimum of 100 mm by 150 mm (4 inch by 6 inch) and shall be tested for a minimum of 300 hours. After exposure, the specimen shall exhibit no observable deterioration, such as chalking, fading, or rust staining.

1.2.3.5 Water Resistance

Test in accordance with ASTM D2247. The specimen shall be a minimum of 100 mm by 150 mm (4 inch by 6 inch). After 14 days, the specimen shall exhibit no cracking, checking, crazing, erosion, blistering, peeling, or delamination.

1.2.3.6 Absorption-Freeze/Thaw

Class PB systems shall be tested in accordance with ASTM E2485 for 60 cycles of freezing and thawing. No cracking, checking, or splitting, and negligible weight gain. Class PM systems shall be tested in accordance with ASTM C67 for 50 cycles of freezing and thawing. After testing, the specimens shall exhibit no cracking or checking and have negligible weight gain.

1.2.3.7 Sample Boards

Unless otherwise stated, provide sample EIFS Component 300 by 600 mm (12 by 24 inches), on sheathing board, including finish color and texture, typical joints and sealant. If more than one color, finish, or pattern is used, provide one sample for each. The test specimen shall consist of reinforcing mesh, base coat, and finish coat applied in accordance with manufacturer's printed recommendations to the insulation board to be used on the building.

1.2.4 Moisture Analysis

Prepare and submit a job specific vapor transmission analysis based on project specific climate and specified wall components and materials. Indicate the temperature and relative humidity for both inside and outside of the building; a complete listing of the building components, their thickness, thermal resistance and permeance, as well as building location and use. If a mathematical model was used for the analysis, include the name of the model and the supplier/developer.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop drawings; G

SD-03 Product Data

Sheathing board
Thermal insulation
Adhesive
Accessories
Base coat
Reinforcing fabric
Finish coat
Joint SealantInsulation Board
Warranty

SD-05 Design Data

Moisture analysis Calculations

SD-06 Test Reports

Abrasion resistance
Accelerated weathering
Impact resistance
Mildew resistance
Salt spray resistance
Absorption-freeze-thaw
Wall fire test
Wind load
Water penetration
Water resistance
Surface Burning Characteristics

SD-07 Certificates

Qualifications of EIFS Manufacturer
Qualification of EIFS Installer
Qualification of Sealant Applicator

SD-08 Manufacturer's Instructions

Installation of EIFS

SD-10 Operation and Maintenance Data

Maintenance of EIFS

1.4 QUALITY ASSURANCE

1.4.1 Qualifications of EIFS Manufacturer

Submit certification that the EIFS is the product of a manufacturer who has been in the practice of manufacturing and designing EIFS for a period of not less than 3 years, and has been involved in at least five projects similar to this project in size, scope, and complexity, in the same or a similar climate as this project.

1.4.2 Qualification of EIFS Installer

Submit certification that the EIFS Installer has been trained by the EIFS manufacturer to perform the installation of the System and shall have successfully installed at least five projects at or near the size and complexity of this project. The contractor shall employ qualified workers trained and experienced in installing the manufacturer's EIFS.

1.4.3 Qualification of Sealant Applicator

Submit certification that the sealant applicator is experienced and competent in the installation of high performance industrial and commercial sealants and shall have successfully installed at least five projects at or near the size and complexity of this project and that sealant applicator has been approved by the EIFS Manufacturer.

1.4.4 Qualifications of Third Party Inspector

Submit evidence that third party inspector has current certification from the Exterior Design Institute or equal inspector certification as inspector for the installation of EIFS.

1.4.5 Insulation Board

Insulation Board shall be approved and labeled under third party quality program as required by applicable building code.

1.4.6 Pre-Installation Conference

After approval of submittals and before commencing any work on the EIFS , including installation of any sheathing board, insulation, and associated work, the Contracting Officer will hold a pre-installation conference to review:

a. Drawings, specifications, and samples;

b. Procedure for on-site inspection and acceptance of EIFS substrate and pertinent details (for example, mock-up installation);

c. Contractor's plan for coordination of work of the various trades involved in providing EIF system and other components;

d. Inspection procedures; and

e. Safety requirements.

Pre-installation conference shall be attended by the Contractor and all personnel directly responsible for installation of the EIF system, including sealant applicator, and personnel responsible for related work, such as flashing and sheet metal, windows and doors, and a representative of the EIFS manufacturer. Before beginning EIFS work, the contractor shall confirm in writing the resolution of conflicts among those attending the pre-installation conference.

1.5 DELIVERY AND STORAGE

Deliver materials to job site in original unopened packages, marked with manufacturer's name, brand name, and description of contents. Store materials off the ground and in accordance with the manufacturer's recommendations in a clean, dry, well-ventilated area. Protect stored materials from rain, sunlight, and excessive heat. Keep coating materials which would be damaged by freezing at a temperature not less than 4 degrees C (40 degrees F). Do not expose insulation board to flame or other ignition sources.

1.6 ENVIRONMENTAL CONDITIONS

a. Do not prepare materials or apply EIFS during inclement weather unless appropriate protection is provided. Protect installed materials from inclement weather until they are dry.

b. Apply sealants and wet materials only at ambient temperatures of 4 degrees C (40 degrees F) or above and rising, unless supplemental heat is provided. The system shall be protected from inclement weather and to maintain this temperature for a minimum of 24 hours after installation.

c. Do not leave insulation board exposed to sunlight after installation.

1.7 WARRANTY

Furnish manufacturer's standard warranty for the EIFS. Warranty shall be issued directly to Government and cover a period of not less than 5 years from date Government accepted the work.

PART 2 PRODUCTS

2.1 COMPATIBILITY

Provide all materials compatible with each other and with the substrate, and as recommended by EIFS manufacturer.

2.2 SHEATHING BOARD

2.2.1 Fiber Reinforced Cement Sheathing Board

a. Meet ASTM C1186, Type A, Grade I, or.

b. Meet ASTM C1325, Type A, Flexural Strength as indicated.

c. Non-combustible per ASTM E136.

d. Nail Pull Resistance: No less than 534 N (120 lb) when tested in accordance with ASTM C473.

e. Thickness no less than 13 mm (1/2 inch).

f. Water Absorption not to exceed 17 percent.

2.2.2 Glass Mat Gypsum Sheathing Board

a. Conform to ASTM C1177/C1177M; or.

b. ASTM C1278/C1278M, Water Resistant Exterior Type only

c. Flexural Strength as indicatedd. Nail Pull Resistance: No less than 534 N (120 lb) when tested in accordance with ASTM C473.

2.3 ADHESIVE

Manufacturer's standard product, including primer as required, and shall be compatible with substrate and insulation board to which the system is applied.

2.4 LATHING AND FURRING

Conform to ASTM C847, 1.4 kg/sqm (2.5 lb/sqyd), self-furring, galvanized.

2.5 MECHANICAL FASTENERS

Corrosion resistant and as approved by EIFS manufacturer. Select fastener type and pattern based on applicable wind loads and substrate into which fastener will be attached, to provide the necessary pull-out, tensile, and shear strengths.

2.6 THERMAL INSULATION

2.6.1 Manufacturer's Recommendations

Provide only thermal insulation recommended by the EIFS manufacturer for the type of application intended.

2.6.2 Insulation Board

Insulation board shall be standard product of manufacturer and shall be compatible with other systems components. Boards shall be factory marked individually with the manufacturer's name or trade mark, the material specification number, the R-value at 24 degree C (75 degrees F), and thickness. No layer of insulation shall be less than 20 mm (3/4 inch) thick. The maximum thickness of all layers shall not exceed 100 mm (4 inches) Insulation Board shall be certified as aged, in block form, prior to cutting and shipping, a minimum of 6 weeks by air drying, or equivalent.

a. Thermal resistance: As indicated

b. Insulating material: ASTM C578 Type I or KS M 3808 as recommended by the EIFS manufacturer and treated to be compatible with other EIFS components. Age insulation by air drying a minimum of 6 weeks prior to cutting and shipping.

c. Drainage: Preform channels into the interior face of insulation board or provide polypropylene drainage lath spacer to provide water drainage system.

2.7 BASE COAT

Manufacturer's standard product and compatible with other systems components.

2.8 PORTLAND CEMENT

Conform to ASTM C150/C150M or KS L 5201, Type I or II as required, fresh and free of lumps, and approved by the systems manufacturer.

2.9 REINFORCING FABRIC

Reinforcing fabric mesh shall be alkali-resistant, balanced, open weave , glass fiber fabric made from twisted multi-end strands specifically treated for compatibility with the other system materials, and comply with ASTM E2098 and as recommended by EIFS manufacturer.

2.10 FINISH COAT

Manufacturer's standard product conforming to the requirements in the paragraph on Sub-Component Requirements and Tests. For color consistency, use materials from the same batch or lot number.

2.11 SEALANT PRIMER

Non-staining, quick-drying type recommended by sealant manufacturer and EIFS manufacturer.

2.12 ACCESSORIES

Conform to recommendations of EIFS manufacturer, including trim, edging, anchors, and expansion joints. All metal items and fasteners to be corrosion resistant.

2.13 JOINT SEALANT

Non-staining, quick-drying type meeting ASTM C920, as Type S or M, minimum Grade NS, minimum Class 25 and compatible with the finish system type and grade or KS F 4910, and recommended by both the sealant manufacturer and EIFS manufacturer.

2.14 BOND BREAKER

As required by EIFS manufacturer and recommended by sealant manufacturer and EIFS manufacturer.

2.15 BACKER ROD

Closed cell polyethylene free from oil or other staining elements and as recommended by sealant manufacturer and EIFS manufacturer. Do not use absorptive materials as backer rod. The backer rod should be sized 25 percent larger than the width of the joint.

2.16 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Examine substrate and existing conditions to determine that the EIFS can be installed as required by the EIFS manufacturer and that all work related to the EIFS is properly coordinated. Surface shall be sound and free of oil, loose materials or protrusions which will interfere with the system installation. If deficiencies are found, notify the Contracting Officer and do not proceed with installation until the deficiencies are corrected. The substrate shall be plane, with no deviation greater than 6 mm (1/4 inch) when tested with a 3 m (10 foot) straightedge. Determine flatness, plumbness, and any other conditions for conformance to manufacturer's instructions.

3.2 SURFACE PREPARATION

Prepare existing surfaces for application of the EIFS to meet flatness tolerances and surface preparation according to manufacturer's installation instructions but provide a flatness of not more that 6 mm in 3000 mm (1/4 inch in 10 feet). Provide clean surfaces free of oil and loose material without protrusions adversely affecting the installation of the insulation board. For adhesively attached EIFS, existing deteriorated paint must be removed. Due to substrate conditions or as recommended by the system manufacturer, a primer may be required. Apply the primer to existing surfaces as recommended by the manufacturer. Use masking tape to protect areas adjacent to the EIFS to prevent base or finish coat to be applied to areas not intended to be covered with the EIFS. The contractor shall not proceed with the installation until all noted deficiencies of the substrate are corrected.

3.3 INSTALLATION

Submit shop drawings showing wall layout, construction and expansion joints, decorative grooves, layout of sheathing board, thermal insulation board, and reinforcing mesh and strip reinforcing fabric; joint and flashing details; details at wall penetrations; types and location of fasteners; details at windows and doors; and details at base, roof, parapet, corners, and other details as needed.

Install EIFS as indicated, comply with manufacturer's instructions except as otherwise specified, and in accordance with approved shop drawings. EIFS shall be installed only by an applicator trained by the EIFS manufacturer. Specifically, include all manufacturer recommended provisions regarding flashing and treatment of wall penetrations.

Submit manufacturer's standard printed instructions for the installation of the EIFS. Include requirements for condition and preparation of substrate, installation of EIFS, and requirements for sealants and sealing.

3.3.1 Sheathing Board

Edges and ends of boards shall be butted snugly with vertical joints staggered to provide full and even support for the insulation. Do not align sheathing board joints with wall openings. Provide support at both vertical and horizontal joints. Attach sheathing board to metal studs with self-tapping drywall screws or to concrete or masonry with corrosion resistant metal fasteners. Place fasteners sufficiently close to support imposed loads, but not more than:

a. Maximum of 200 mm (8 inches) apart on each supporting stud

b. Maximum of 300 mm (12 inches) apart horizontally and vertically into concrete or masonry.

Space fasteners more closely when required for negative wind load resistance.

3.3.2 Insulation Board

Unless otherwise specified by the system manufacturer, place the long edge horizontally from level base line. Stagger vertical joints and interlock at corners. Butt joints tightly. Provide flush surfaces at joints. Offset insulation board joints from joints in sheathing by at least 200 mm

(8 inches). Align drainage channels of integral drainage system or provide polypropylene drainage lath space to provide a path for any water weeped from behind the insulation to escape wall construction. Use L-shaped insulation board pieces at corners of openings. Joints of insulation shall be butted tightly. Surfaces of adjacent insulation boards shall be flush at joints. Gaps greater than 1.6 mm (1/16 inch) between the insulation boards shall be filled with slivers of insulation. Uneven board surfaces with irregularities projecting more than 1.6 mm (1/16 inch) shall be rasped in accordance with the manufacturer's instructions to produce an even surface. Attach insulation board as recommended by manufacturer. The adhered insulation board shall be allowed to remain undisturbed for 24 hours prior to proceeding with the installation of the base coat/reinforcing mesh, or longer if necessary for the adhesive to dry. However, do not leave insulation board exposed longer than recommended by insulation manufacturer.

3.3.2.1 Mechanically Fastened Insulation Boards

Fasten with manufacturer's standard corrosion resistant anchors, spaced as recommended by manufacturer, but not more than 600 mm (2 feet) horizontally and vertically.

3.3.2.2 Adhesively Fastened Insulation Boards

Apply insulation board using adhesive spread with a notched trowel to the back of the insulation boards in accordance with the manufacturer’s instructions.

3.3.3 Base Coat and Reinforcing Fabric Mesh,

3.3.3.1 Class PB Systems

Allow the adhered insulation board to dry for 24 hours, or longer if necessary, prior to proceeding with the installation of the base coat/reinforcing fabric mesh Install reinforcing fabric in accordance with manufacturer's instructions. Mix base coat in accordance with the manufacturer's instructions and apply to insulated wall surfaces to the thickness specified by the system manufacturer and provide any other reinforcement recommended by EIFS manufacturer. Trowel the reinforcing fabric mesh into the wet base coat material. Fully embed the mesh in the base coat. When properly worked-in, the pattern of the reinforcing fabric mesh shall not be visible. Provide diagonal reinforcement at opening corners. Back-wrap or edge wrap all terminations of the EIFS. Overlap the reinforcing fabric mesh a minimum of 60 mm (2.5 inches) on previously installed mesh, or butted, in accordance with the manufacturer’s instructions.

3.3.3.2 Class PM Systems

Mechanically fasten reinforcing fabric mesh to the insulated wall using the type and spacing of fasteners specified in the manufacturer’s instructions. Provide diagonal reinforcement at opening corners. Mix base coat in accordance with manufacturer's instructions. Apply base coat in accordance with manufacturer's instruction to provide a complete, tight coating of uniform thickness as specified by the manufacturer. Cover all fiberglass reinforcing fabric, including at back wrapped areas at panel joints and at fasteners.

3.3.4 Finish Coat

The base coat/reinforcing mesh must be allowed to dry a minimum of 24 hours prior to application of the finish coat. Surface irregularities in the base coat, such as trowel marks, board lines, reinforcing mesh laps, etc., shall be corrected prior to the application of the finish coat. Apply and level finish coat in one operation. Obtain final texture by trowels, floats, or by spray application as necessary to achieve the required finish as approved. Apply the finish coat to the dry base coat maintaining a wet edge at all times to obtain a uniform appearance. The thickness of the finish coat shall be in accordance with the system manufacturer’s current published instructions. Apply finish coat so that it does not cover surfaces to which joint sealants are to be applied.

3.4 JOINT SEALING

Seal EIFS at openings as recommended by the system manufacturer. Apply sealant only to the base coat or base coat with EIFS Manufacturer's color coating. Do not apply sealant to the finish coat.

3.4.1 Surface Preparation, Backer Rod, and Primer

Immediately prior to application, remove loose matter from joint. Ensure that joint is dry and free of finish coat, or other foreign matter. Install backer rod. Apply primer as required by sealant and EIFS manufacturer. Check that joint width is as shown on drawings but in no case shall it be less than 13 mm (0.5 inch) for perimeter seals and 20 mm (0.75 inch) for expansion joints. The width shall not be less than 4 times the anticipated movement. Check sealant manufacturer's recommendations regarding proper width to depth ratio.

3.4.2 Sealant

Do not apply sealant until all EIFS coatings are fully dry. Apply sealant in accordance with sealant manufacturer's instructions with gun having nozzle that fits joint width. Do not use sealant that has exceeded shelf life or cannot be discharged in a continuous flow. Completely fill the joint solidly with sealant without air pockets so that full contact is made with both sides of the joint. Tool sealant with a round instrument that provides a concave profile and a uniformly smooth and wrinkle free sealant surface. Do not wet tool the joint with soap, water, or any other liquid tooling aid. During inclement weather, protect the joints until sealant application. Use particular caution in sealing joints between window and door frames and the EIFS wall and at all other wall penetrations. Clean all surfaces to remove excess sealant.

3.5 FIELD QUALITY CONTROL

Throughout the installation, the contractor shall establish and maintain an inspection procedure to assure compliance of the installed EIFS with contract requirements. Work not in compliance shall be removed and replaced or corrected in an approved manner. The inspection procedures, from acceptance of deliveries through installation of sealants and final acceptance shall be performed by qualified inspector trained by the manufacturer. No work on the EIFS shall be performed unless the inspector is present at the job site.

3.5.1 Inspection Check List

During the installation and at the completion of installation, perform inspections covering at the minimum all applicable items enumerated on the attached check list. The inspector shall initial and date all applicable items, sign the check list, and submit it to the Contracting Officer at the completion of the EIFS erection.

CHECK LIST

Item	Description	Appr'd/Date
a.	Materials are handled and stored correctly.	
b.	Environmental conditions are within specified limits, including temperature not below 4 degrees C (40 degrees F), and the work is protected from the elements as required.	
c.	Preparation and installation is performed by qualified personnel using the correct tools.	
d.	Adjacent areas to which EIFS is not to be applied (such as on window and door frames) are protected with masking tape, plastic films, drop cloths, etc. to prevent accidental application of EIFS materials.	
e.	Control, expansion and aesthetic joints are installed as indicated or recommended. Accessories are properly installed.	
f.	Substrate is in-plane, properly attached, clean, dry, and free of contaminants. Concrete substrate is free of efflorescence.	
g.	Materials are mixed thoroughly and in proper proportions.	
h.	Adhesive is applied in sufficient quantity with proper-size notched trowel.	
i.	Mechanical attachments have proper spacing, layout and fastener depth.	
j.	Insulation boards are tightly abutted, in running bond pattern, with joints staggered with the sheathing, board corners interlocked, L-shaped boards around openings, edges free of adhesive, and provision for joints. Gaps are filled and surfaces rasped.	
k.	Insulation adhesive must be allowed to dry (a minimum of 24-hours) prior to the application of the base coat.	
l.	Reinforcing fabric mesh is properly back-wrapped at terminations.	
m.	Reinforcing fabric mesh is fully embedded and properly placed. Corners are reinforced. Openings are diagonally reinforced. Mesh overlaps minimum 65 mm (2-1/2 inches).	

CHECK LIST

Item	Description	Appr'd/Date
n.	Base coat thickness is within specified limits.	
o.	The base coat/reinforcing fabric mesh must be allowed to dry (a minimum of 24-hours) prior to the application of the finish coat.	
p.	Finish coat is applied with sufficient number of personnel and stopped at suitable points. Floats and methods of texturing are uniform.	
q.	All flashings are properly installed.	
r.	All joints are properly sealed in their entire length at time and under environmental conditions as specified by the manufacturer.	
s.	All scaffolding, equipment, materials, debris and temporary protection are removed from site upon completion.	

Name of Inspector:________________ Signed:__________________
Date:________

3.6 CLEANUP

Upon completion, remove all scaffolding, equipment, materials and debris from site. Remove all temporary protection installed to facilitate installation of EIFS.

3.7 Maintenance of EIFS

Submit instructions including detailed finish repair procedures and information regarding compatibility of sealants with base and finish coatings. Include joint and other details, such as end conditions, corners, windows, and parapet. Include shelf life and recommended cleaning solvents in data for sealants. Include material safety data sheets (MSDS) for all components of the EIFS.

-- End of Section --

SECTION 07 31 13

ASPHALT SHINGLES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1970/D1970M	(2011) Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D3018/D3018M	(2011) Standard Specification for Class A Asphalt Shingles Surfaced With Mineral Granules
ASTM D3161	(2009) Standard Test Method for Wind-Resistance of Asphalt Shingles (Fan-Induced Method)
ASTM D3462/D3462M	(2010a) Standard Specification for Asphalt Shingles Made From Glass Felt and Surfaced with Mineral Granules
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D4586	(2007) Asphalt Roof Cement, Asbestos-Free
ASTM D4869/D4869M	(2005e1; R 2011) Standard Specification for Asphalt-Saturated Organic Felt Underlayment Used in Steep Slope Roofing
ASTM D6380	(2003; R 2009) Standard Specification for Asphalt Roll Roofing (Organic Felt)

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4750	(2007) Asphalt Shingles
KS F 4901	(2012) Asphalt Roofing Felts (Fiber Base, Saturated Bitumen Felts)
KS F 4906	(2012) Sanded Roofing
KS M 2270	(2007) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing

UNDERWRITERS LABORATORIES (UL)

UL 790	(2004; Reprint Oct 2008) Standard Test Methods for Fire Tests of Roof Coverings

1.2 DEFINITIONS

1.2.1 Top Lap

That portion of shingle overlapping shingle in course below.

1.2.2 Head Lap

The triple coverage portion of top lap which is the shortest distance from the butt edge of an overlapping shingle to the upper edge of a shingle in the second course below.

1.2.3 Exposure

That portion of a shingle exposed to the weather after installation.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Shingles

1.4 DELIVERY AND STORAGE

Deliver materials in the manufacturer's unopened bundles and containers bearing the manufacturer's brand name. Keep materials dry, completely covered, and protected from the weather. Store according to manufacturer's written instructions. Roll goods shall be stored on end in an upright position or in accordance with manufacturer's recommendations. Immediately before laying, roofing felt shall be stored for 24 hours in an area maintained at a temperature not lower than 10 degrees C (50 degrees F).

1.5 WARRANTIES

Warranties shall begin on the date of Government acceptance of the work.

1.5.1 Manufacturer's Warranty

Furnish the asphalt shingle manufacturer's standard 25 year warranty for the asphalt shingles. The warranty shall run directly to the Government.

1.5.2 Contractor's Warranty

The Contractor shall warrant for 5 years that the asphalt shingle roofing system, as installed, is free from defects in workmanship. When repairs due to defective workmanship are required during the Contractor's warranty period, the Contractor shall make such repairs within 72 hours of notification. When repairs are not performed within the specified time, emergency repairs performed by others will not void the warranty.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Shingles

Submit data including type, weight, class, UL labels, and special types of underlayment and eave flashing.

Mineral granule-surfaced asphalt shingles, self-sealing, square tab, strip, fungus-resistant. ASTM D3018/D3018M, Type I, and ASTM D3462/D3462M, weighing not less than 10.3 kilograms per square meter (210 pounds per 100 square feet), or KS F 4750. Shingles shall meet the fire resistance requirements of UL 790 for Class A and the wind resistance requirements of ASTM D3161, Class F. Color shall be as selected from the manufacturer's standard color charts. Shingle color shall be as indicated..

2.1.2 Mineral-Surfaced Asphalt Roll Roofing

ASTM D6380 or KS F 4906.

2.1.3 Smooth-Surfaced Asphalt Roll Roofing

ASTM D6380, Type II or KS F 4901.

2.1.4 Underlayment

Asphalt-saturated felt conforming to ASTM D4869/D4869M or ASTM D226/D226M, Type I, number 15, or KS F 4901 without perforations or other material specified by the shingle manufacturer for use as underlayment, unless otherwise indicated.

2.1.4.1 Leak Barrier Underlayment

Self-adhering leak barrier or ice dam underlayment shall comply with ASTM D1970/D1970M for sealability around nails.

2.1.5 Self-Adhering Membrane

Self-adhering rubberized asphaltic membrane, a minimum of one mm (40 mils) thick, and recommended by the shingle manufacturer for use as eaves flashing.

2.1.6 Nails for Applying Shingles and Asphalt-Saturated Felt

Aluminum or hot-dipped galvanized steel or equivalent corrosion resistant with sharp points and flat heads 10 to 11 mm (3/8 to 7/16 inch) in diameter. Shank diameter of nails shall be a minimum of 2.67 mm (0.105 inch) and a maximum of 3.43 mm (0.135 inch) with garb or otherwise deformed for added pull-out resistance. Nails shall be long enough to penetrate completely through or extend a minimum of 20 mm (3/4 inch) into roof deck, whichever is less, when driven through materials to be fastened.

2.1.7 Asphalt Roof Cement

ASTM D4586, Type II.

2.1.8 Asphalt Primer

ASTM D41/D41M or KS M 2270.

2.1.9 Ventilators

2.1.9.1 Nailable Plastic Shingle Over Type Ridge Vents

Ridge vents shall be constructed of UV stabilized nailable rigid polypropylene material, approximately 0.30 m (1 foot) wide and 25 mm (1 inch) thick, and shall be in 1.2 m (4 foot) long interlocking sections with self-aligning ends or corrugated polyethylene rigid roll or rigid strip ridge vent with aluminum wind deflectors on each side. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.1.9.2 Nailable Mesh Shingle Over Type Ridge Vents

Ridge vents shall be constructed of UV stabilized nailable polyester mesh material, approximately 0.30 m (one foot) wide. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

Ensure that roof deck is smooth, clean, dry, and without loose knots. Roof surfaces shall be firm and free from loose boards, large cracks, and projecting ends that might damage the roofing. Vents and other projections through roofs shall be properly flashed and secured in position, and projecting nails shall be driven flush with the deck.

3.2 SURFACE PREPARATION

Cover knotholes and cracks with sheet metal nailed securely to sheathing. Flash and secure vents and other roof projections, and drive projecting nails firmly home.

3.3 APPLICATION

Apply roofing materials as specified herein unless specified or recommended otherwise by shingle manufacturer's written instructions.

3.3.1 Underlayment

Provide for roof slopes one in three (4 inches per foot) and greater. Apply one layer of shingle underlayment to roof deck. Lay underlayment parallel to roof eaves, starting at eaves. Provide minimum 50 mm (2 inch) head laps, 100 mm (4 inch) end laps, and 150 mm (6 inch) laps from both sides over hips and ridges. Nail sufficiently to hold until shingles are applied. Turn up vertical surfaces a minimum of 100 mm (4 inches).

Provide for roof slopes as indicated. Apply two layers to roof deck. Provide a 480 mm (19 inch) wide strip as starter sheet to maintain specified number of layers throughout roof. Lay parallel to eaves, starting at eaves. Provide minimum 480 mm (19 inch) head laps, 150 mm (6 inch) laps from both sides over hips and ridges, and 300 mm (12 inch) end laps in the field of the roof. Nail sufficiently to hold until shingles are applied. Turn up vertical surfaces a minimum of 100 mm (4 inches). When a self-adhering membrane is used for eave flashing, start underlayment from upper edge of eave flashing.

3.3.2 Drip Edges

Provide metal drip edges as specified in Section 07 60 00 FLASHING AND SHEET METAL applied directly on the wood deck at eaves and over the underlayment at rakes. Extend back from edge of deck a minimum of 75 mm (3 inches), and secure with nails spaced a maximum of 100 millimeters (4 inches) o.c. along inner edge.

3.3.3 Starter Strip

Apply starter strip at eaves, using 225 mm (9 inch) wide strip of mineral-surfaced roll roofing of a color to match shingles. Optionally, use a row of shingles with tabs removed and trimmed to ensure that joints are not exposed at shingle cutouts. Apply starter strip along eaves, overlaying and finishing even with lower edge of eave flashing strip; fasten in a line parallel to and 75 to 100 mm (3 to 4 inches) above eave edge. Place nails so top of nail is not exposed in cutouts of first course of shingles. Fasten with 6 nails per strip of shingles or space nails at 150 mm (6 inches) o.c. for roll roofing. Seal tabs of first course of shingles with asphalt roof cement as specified below.

3.3.4 Shingle Courses

Start first course with full shingle, and apply succeeding courses with joints staggered at thirds or halves. Butt-end joints of shingles shall not align vertically more often than every fourth course. Apply shingle courses as follows:

a. Fastening: Do not drive fasteners into or above the factory-applied adhesive unless adhesive is located 16 mm (5/8 inch) or closer to top of cutouts. Place fasteners so they are concealed by shingle top lap and penetrate the head lap.

b. Shingles applied with nails: Nominal 125 mm (5 inch) exposure. Apply each shingle with minimum of four nails. Place one nail 25 mm (one inch) from each end, and evenly space nails on a horizontal line a minimum of 16 mm (5/8 inch) above top of cutouts.

c. Nailing: Apply shingles with nominal 125 mm (5 inch) exposure. Apply each shingle with minimum of six nails. Place one nail 25 mm (one inch) from each end and one nail on each side of each cutout, on a horizontal line 16 mm (5/8 inch) above cutouts.

d. Sealing: Seal each tab with continuous, 225 mm (9 inch)long, 6 mm (1/4 inch) diameter bead of asphalt roof cement, applied to the surface of course below. Place bead on horizontal line 16 mm (5/8 inch) above cutouts so bead will be 25 mm (one inch) from bottom edge of tab to be sealed and so bead will not show through cutouts. After nailing each shingle, press tabs down to ensure spreading and bonding of asphalt roof cement.

3.3.5 Hips and Ridges

Form with 225 by 300 mm (9 by 12 inch) individual shingles or with 300 by 300 mm (12 by 12 inch) shingles cut from 300 by 900 mm (12 by 36 inch) strip shingles. Bend shingles lengthwise down center with equal exposure on each side of hip or ridge. Lap shingles to provide a maximum 125 mm (5 inch) exposure, and nail each side in unexposed area 140 mm (5-1/2 inches) from butt and 25 mm (one inch) in from edge.

3.3.6 Valleys

Provide either closed cut, woven, open roll roofing, or open sheet metal valleys.

3.3.6.1 Closed Cut Valleys

Provide 900 mm (36 inch) wide valley lining of single layer of smooth-surfaced or mineral-surfaced roll roofing, with mineral-surface facing down, for full length of valley as follows:

a. Center lining in valley over underlayment. Provide minimum 300 mm (12 inch) end laps in the lining and seal laps with asphalt roof cement. Fasten lining to hold it in place until shingles are applied.

b. Apply first regular course of shingles along eaves of one of the intersecting roof planes and across valley. Extend course at least 300 mm (12 inches) onto adjoining roof.

c. Apply succeeding courses in same manner as first course, extending across valley and onto adjoining roof.

d. Press shingles tightly into valley and nail in normal manner, except apply nails not closer than 150 mm (6 inches) to valley centerline, and apply additional nail in top corner of each shingle crossing valley.

e. Apply shingles on the adjoining roof plane, starting along eaves and across valley onto previously applied shingles. Trim overlapping courses back to a line parallel to and a minimum of 50 mm (2 inches) back from valley centerline.

f. Trim 25 mm (one inch) on a 45 degree angle from upper corner of each end shingle. Embed end shingles in a 75 mm (3 inch) wide band of asphalt roof cement.

3.3.6.2 Woven Valleys

Provide valley lining as specified for closed cut valley. Lay valley shingles over lining by either of the following methods:

a. Method I: Apply regular shingles on both roofs simultaneously. Weave each course in turn over the valley. Lay the first regular course of shingles along eaves of roof up to and over valley. Extend course along adjoining roof deck at least 300 mm (12 inches). Carry first regular course of shingles of adjoining roof over valley on top of previously applied shingles. Lay succeeding courses alternately, weaving valley shingles over each other for full length of valley.

b. Method II: Apply regular shingles on each roof surface separately to a line about 900 mm (3 feet) from center of valley, and weave valley shingles in place later, as specified for Method I.

In following either method, press shingles tightly into valley, and fasten in normal manner; except apply nails not closer than 150 mm (6 inches) to valley centerline, and apply additional nail in top corner of terminal shingle on both sides of valley.

3.3.6.3 Open Roll Roofing Valleys

Provide 450 mm (18 inch) wide strip of mineral-surfaced asphalt roll roofing, of a color to blend with asphalt shingles, and with granular surface facing down, for the full length of valley as follows:

a. Center roll roofing strip in valley over underlayment. Lay centered in valley over felt underlayment and with granular face down. Nail strip only enough to hold in place. Apply nails in rows 25 mm (one inch) from each edge. As fastening along second side proceeds, press strip firmly into valley.

b. Center second strip 900 mm (36 inches) wide in valley and lay it over first strip with granular face exposed and nail as specified for 450 mm (18 inch) strip.

c. Before applying roofing shingles, snap two chalk lines for full length of valley. Locate each line 75 mm (3 inches) from centerline of valley at top, and increase width between lines by 25 mm for each 2440 mm (one inch for each 8 feet) of valley length, continuing to eaves.

d. Apply a 50 mm (2 inch) band of asphalt roof cement along each edge of 900 mm (36 inch) strip from edge to chalk line. Cut regular shingle courses true along valley chalk lines, and nail in normal manner.

3.3.6.4 Open Sheet Metal Valleys

Sheet metal flashing for valleys is specified in Section 07 60 00 FLASHING AND SHEET METAL. Before installing and fastening flashing in place with metal cleats:

a. Install single layer of 900 mm (36 inch) wide, asphalt-saturated felt, centered on valley and extending entire length of valley over felt underlayment.

b. Cut regular shingle courses on each roof on true line 50 mm (2 inches) from valley centerline at top of valley, and increase width between lines by 25 mm for each 2440 mm (one inch for each 8 feet) of valley length, continuing to eaves.

c. Apply 50 mm (2 inch) band of asphalt roof cement over flashing, along and underside of shingles adjoining valley.

d. Press shingles tightly into cement, and nail in normal manner, except apply nails not closer than 125 mm (5 inches) to valley centerline. Do not drive nails through valley flashing.

e. Provide a 100 mm (4 inch) band of asphalt roof cement for fastening shingle tabs down along open metal gutters.

3.3.7 Flashing

3.3.7.1 Eave Flashing

Provide for roof slopes one in 3 (4 inches per foot) and greater, unless otherwise indicated. Provide either of the following types of eave flashing:

a. From the eaves to a point 600 mm (24 inches) inside interior wall line, apply solid coating of asphalt roof cement between overlapping layers of underlayment. Spread cement to a uniform thickness at rate of 7.5 liters per 10 square meters (2 gallons per 100 square feet) of cemented roof area.

b. From the eaves to a point 600 mm (24 inches) inside interior wall line, apply one layer of self-adhering membrane. Follow membrane manufacturer's printed installation instructions.

3.3.7.2 Stepped Flashing

For sloping roofs which abut vertical surfaces, provide stepped metal flashing as specified in Section 07 60 00 FLASHING AND SHEET METAL.

3.3.7.3 Vent and Stack Flashing

Apply shingles up to point where vent or stack pipe projects through roof, and cut nearest shingle to fit around pipe. Before applying shingles beyond pipe, prepare flange of metal pipe vent flashing as specified in Section 07 60 00 FLASHING AND SHEET METAL, by applying a 3 mm (1/8 inch) thick coating of asphalt roof cement on bottom side of flashing flange. Slip flashing collar and flange over pipe, and set coated flange in 2 mm (1/16 inch) coating of asphalt roof cement. After applying flashing flange, continue shingling up roof. Lap lower part of flange over shingles. Overlap flange with side and upper shingles. Fit shingles around pipe, and embed in 2 mm (1/16 inch) thick coating of asphalt roof cement where shingles overlay flange.

3.3.7.4 Chimney Flashing

Provide treated wood crickets as specified in Section 06 10 00 ROUGH CARPENTRY. Provide metal base and counterflashing as specified in Section 07 60 00 FLASHING AND SHEET METAL. Uniformly coat masonry surfaces which are to receive flashing with asphalt primer applied at rate of 4 liters per 10 square meters (one gallon per 100 square feet). Apply shingles over underlayment up to front face of chimney. Apply metal front base flashing with lower section extending at least 100 mm (4 inches) over shingles. Set base flashing in a 2 mm (1/16 inch) coating of asphalt roof cement on shingles and chimney face. Apply metal step flashing at sides in a coating of asphalt roof cement. Embed end shingles in each course that overlaps step flashing with asphalt roof cement. Apply metal rear base flashing over cricket and back of chimney in coating of asphalt roof cement. Apply end shingles in each course up to cricket, and cement in place. Lap base flashing minimum of 75 mm (3 inches) with metal counterflashing.

-- End of Section --

SECTION 07 32 13

ROOF TILES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C1	(2003) All Timber Products - Preservative Treatment by Pressure Processes

ASTM INTERNATIONAL (ASTM)

ASTM C1167	(2011) Standard Specification for Clay Roof Tiles
ASTM C1177/C1177M	(2008) Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C270	(2012) Standard Specification for Mortar for Unit Masonry
ASTM C67	(2014) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM D2178	(2004) Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D4586	(2007) Asphalt Roof Cement, Asbestos-Free
ASTM E108	(2011) Fire Tests of Roof Coverings
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3510	(2004) Clay Roof Tiles
KS F 4029	(2007) Pressed Cement Roof Tiles
KS F 4901	(2012) Asphalt Roofing Felts (Fiber Base,

	Saturated Bitumen Felts)
KS M 2201	(2007) Straight Asphalt

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA 0418	(2009) Steep-slope Roof System Manual

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Clay Tile Roofing System

SD-03 Product Data

Clay Roof Tile
Concrete Roof Tile
Underlayment membrane
Glass mesh mortar units
Fiberglass-faced gypsum roof board
Warranty

SD-07 Certificates

Qualifications of roofing personnel

1.3 DELIVERY AND STORAGE

Deliver materials in the manufacturer's unopened bundles and containers bearing the manufacturer's brand name. Keep materials dry, completely covered, and protected from the weather. Store according to manufacturer's written instructions.

1.4 WARRANTIES

1.4.1 Contractor's Warranty

The Contractor shall warrant for 5 years that the tile roofing system, as installed, is free from defects in workmanship. When repairs due to defective workmanship are required during the Contractor's warranty period, the Contractor shall make such repairs within 72 hours of notification. When repairs are not performed within the specified time, emergency repairs performed by others will not void the warranty.

1.5 COORDINATION

Coordinate with the installation of flashing and gutters provided under Section 07 60 00 FLASHING AND SHEET METAL to ensure proper sequencing. Do not install roofing materials until vent stacks and other penetrations through roof deck have been installed.

1.6 EXTRA STOCK

Provide an extra two percent of each type and color of tile used in clean marked containers. In the extra stock provided, include hip, ridge, and other special shapes in the same proportion as used on the project.

1.7 QUALITY ASSURANCE

1.7.1 Qualifications of Roofing Personnel

Submit documentation showing qualifications of personnel proposed to perform the roofing work and a listing identifying prior installations completed by the Contractor.

1.7.2 Clay Tile Roofing System Drawings

Submit drawings showing clay tile roofing installation and details for appearance, flashing and fastening of tiles.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Clay Roof Tile

ASTM C1167, Grade 1, Machine formed natural clay tiles, One Piece "S" Mission or Two Piece Spanish Mission consisting of a cover and pan tile, kiln-fired to vitrification and free from surface imperfections, or KS F 3510. Provide specially shaped, color-matched units as indicated or required, including hip and ridge covers, rake covers and bird stops. Provide with fastening holes preformed at factory prior to firing.

2.1.2 Concrete Roof Tile

ASTM C67, ASTM E108, or KS F 4029. Extruded, interlocking concrete roofing tile units, shapes as indicated, with integral color, unless otherwise indicated. Include specially shaped, color-matched units as indicated or required for ridges, rakes and hips. Provide with cast-in anchor lugs, transverse weather checks and fastening holes.

2.2 UNDERLAYMENT MEMBRANE

Provide underlayment membrane on surfaces that will be covered with tile. Membrane shall consist of asphalt-saturated felt, unless otherwise indicated.

2.2.1 Asphalt Glass Felt

ASTM D2178, Type VI.

2.2.2 Asphalt-Saturated Felt

Provide Type II, No. 30 asphalt felt in accordance with ASTM D226/D226M or provide asphalt-saturated rag felt conforming to KS F 4901, 30 kg type, or fiberglass mat, Type E glass, Silane sized chopped strand reinforcing mat with a high solubility binder, 0.46 kg per square meter (1-1/2 ounces per square foot).

2.2.3   Flexible Hip and Ridge Flashing

SBS modified rubberized asphalt adhesive on a lineal, low density polyethylene membrane with a 1.52 mm (60 mil) total thickness.

2.2.4   Self-Adhering Membrane Underlayment

ASTM D412, high strength polyethylene-sheet-backed, rubberized asphalt membrane, 1.02 mm (40 mil) thickness.

2.2.5   Primer for Self-Adhering Membrane Underlayment

VOC compliant primer as recommended by membrane manufacturer for application on concrete substrates.

2.3   SUBSTRATE PANELS (FOR APPLICATION OVER STRUCTURAL METAL DECK)

2.3.1   Glass Mesh Mortar Units

ASTM E84, exterior type panels consisting of portland cement, light weight aggregate, with vinyl-coated woven glass fiber mesh imbedded in both surfaces, 11 mm (7/16 inch) thickness by 900 mm (36 inch) width by 1200, 1500, 1800, or 2400 mm (48, 60, 72 or 96 inch) lengths.

2.3.2   Fiberglass-Faced Gypsum Roof Board

ASTM C1177/C1177M, non-structural, fiberglass faced, silicone treated core gypsum panels, 1200 by 2400 by 13 mm (48 by 96 by 1/2 inch) thickness.

2.4   FASTENERS

2.4.1   Nails For Applying Felt Underlayment

Hot dip galvanized steel, 2.9 mm thick (11 gage), sharp pointed, conventional roofing nails with barbed shanks, minimum 9.5 mm (3/8 inch) diameter head, and of sufficient length to penetrate through plywood sheathing. Verify that nails are compatible with flashing materials to prevent galvanic action.

2.4.2   Nails for Installation of Tile

Copper ring shank nails, 3.3 mm (10 gage), with minimum 11 mm (7/16 inch) diameter head or 3.3 mm (10 gage) stainless steel ring shank nails with minimum 9.5 mm (3/8 inch) head and of sufficient length to penetrate 19 mm (3/4 inch) into wood ridge and hip boards or battens. Verify that chemicals used in pressure treatment of ridge and hip boards are compatible with copper nails.

2.4.3   Twisted-Wire Tie System

Continuously twisted 3.3 mm (10 gage) copper or brass, 2.5 mm (12 gage) galvanized steel wire with loops formed at 150 mm (6 inches) on center and with tie wires of 1.8 mm (14 gage) copper or brass or 1.5 mm (16 gage) galvanized steel wire. Provide clips for anchorage of twisted-wire tie system to substrate as recommended by manufacturer.

2.4.4   Single-Line Wire Tie System

3.3 mm (10 gage) copper or brass, or 2.5 mm (12 gage) galvanized steel pre-formed wire ties with a hook on one end and a loop on the other end. Lengths as required for manufacturer's recommended exposure.

2.4.5 Wind Locks

3.3 mm (10 gage) copper or 3.3 mm (10 gage) brass, or 2.5 mm (12 gage) galvanized steel formed wire clips. Select material type as recommended by manufacturer for specific locations.

2.4.6 Hurricane Clips

Tile edge clips fabricated from 1.2 mm (18 gage) brass or 1.05 mm (19 gage) galvanized steel strips, 13 mm (1/2 inch) wide. Provide with two nail holes in horizontal leg for anchorage to deck substrate. Select material type as recommended by manufacturer for specific locations.

2.5 PRESERVATIVE-TREATED LUMBER

AWPA C1, provide treated ridge and hip boards.

2.6 SHEET METAL BIRDSTOP FOR CONCRETE TILE

Formed 0.5 mm (26 gage) galvanized steel "L" section with 75 mm (3 inch) wide horizontal leg and vertical leg cut to conform with bottom profile of tile. Provide pre-finished to match tile color with drain holes punched in vertical leg prior to application of finish.

2.7 MORTAR

ASTM C270, Proportion specification for Type M mortar mix.

2.8 ASPHALT PLASTIC CEMENT

ASTM D4586, Type I or KS M 2201.

2.9 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Examine structural roof deck for compliance with requirements of selected system. Verify that roof penetrations and openings are installed in their proper location.

3.2 PREPARATION

3.2.1 Cleaning

Clean structural deck surfaces to receive substrate panels or underlayment.

3.3 INSTALLATION

Comply with manufacturer's installation instructions and recommendations, but not less than recommended by NRCA 0418. Comply with local building code requirements for special fastening requirements such as wind locks and hurricane clips in high wind areas.

3.3.1 Substrate Panels

Install glass mesh mortar units or fiberglass-faced gypsum roof boards over corrugated metal structural deck as recommended by panel manufacturer.

3.3.2 Felt Underlayment

Apply one layer of felt underlayment horizontally over entire surface to receive roofing tile, lapping succeeding courses a minimum of 50 mm (2 inches), end laps a minimum of 150 mm (6 inches), and hips and valleys a minimum of 300 mm (12 inches). Fasten felt with sufficient number of roofing nails to hold underlayment in place until roofing tile installation. Provide additional layer of felt underlayment when recommended by roof tile manufacturer.

3.3.3 Self-Adhering Membrane Underlayment

Apply self-adhering membrane over wood deck, concrete deck, or substrate panels in accordance with manufacturers recommendations. Provide manufacturer recommended primer for application on concrete surfaces.

3.3.4 Clay Roofing Tile Installation

Beginning at eaves, install roofing tiles as indicated and in accordance with recommendations of the tile manufacturer and fastening system manufacturer. Sawcut tiles at hips valleys and ridges. Cut tile at valleys to form a straight border. Taper valleys from a 50 mm (2 inch) exposure on each side of valley at top and increase exposure 25 mm (one inch), each side, per 2400 mm (8 feet) of valley length. Apply flexible hip and ridge flashing over ridge and hip boards and top edge of tile. Apply asphalt plastic cement at lap between tiles at hip and ridge. Nail hip and ridge tiles to hip and ridge boards.

3.3.5 Batten Installation for Concrete Roofing Tile

Install 19 by 38 mm (1 by 2 inches) treated wood battens with 13 mm (1/2 inch) drain slots at 1200 mm (4 feet) o.c. horizontally. At eave provide 38 by 38 mm (2 by 2 inches) treated wood starter strip. Provide sheet metal bird stops at eave for "S" Type mission tile. At metal structural decks, attach battens with self-tapping screws through substrate panels into metal deck.

3.3.6 Concrete Roofing Tile Installation

Beginning at eaves, install roofing tiles as indicated and in accordance with manufacturers recommendations. Hook mounting lugs over wood battens and nail through each tile into batten. Sawcut tiles at valleys to form a straight border. Taper valleys from a 50 mm (2 inch) exposure on each side of valley at the top and increase exposure by 25 mm (one inch), each side, per 2400 mm (8 feet) of valley length. Apply flexible hip and ridge flashing over ridge and hip boards and top edge of tile. Apply asphalt plastic cement between tiles at hip and ridge. Nail hip and ridge tiles to hip and ridge boards.

3.3.7 CLEANING

Remove mortar and asphalt plastic cement spatter from exposed surfaces of tiles. Upon completion of work, remove excess materials and all refuse generated by the work of this section.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of English unit measurement, and not on metric measurement commonly agreed to by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

Products	English Units	Metric Units
Nails - diameter	11 gage	2.9 mm
head diameter	3/8 inch	9.5 mm
Nails - diameter	10 gage	3.3 mm
head diameter	7/16 inch	11 mm
Wire	10 gage	3.3 mm
	12 gage	2.5 mm
	14 gage	1.8 mm
	0.037 inch	9.4 mm
	0.084 inch	2.13 mm
Edge Clips	18 gage	1.2 mm
	19 gage	1.05 mm
	0.042 inch	1.07 mm
	1/2 inch	13 mm
Bird stop	26 gage	0.5 mm

-- End of Section --

SECTION 07 41 13

METAL ROOF PANELS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI S100	(2007; Supp 1: 2009; Supp 2: 2010) North American Specification for the Design of Cold-Formed Steel Structural Members
AISI SG03-3	(2002; Suppl 2001-2004; R 2008) Cold-Formed Steel Design Manual Set

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS A5.1/A5.1M	(2004) Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2008) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A463/A463M	(2010) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A653/A653M	(2013) Standard Specification for Steel

	Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A755/A755M	(2011) Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C552	(2014) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C792	(2004; R 2008) Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1308	(2002; R 2007) Effect of Household Chemicals on Clear and Pigmented Organic Finishes
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1667	(2005; R 2011) Flexible Cellular Materials - Poly (Vinyl Chloride) Foam (Closed-Cell)
ASTM D1970/D1970M	(2011) Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
ASTM D2244	(2011) Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D2247	(2011) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in

	Roofing and Waterproofing
ASTM D2794	(1993; R 2010) Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D3359	(2009; E 2010; R 2010) Measuring Adhesion by Tape Test
ASTM D3363	(2005e1; R 2011) Film Hardness by Pencil Test
ASTM D4214	(2007) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D4587	(2011) Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings
ASTM D4637/D4637M	(2012) EPDM Sheet Used in Single-Ply Roof Membrane
ASTM D4869/D4869M	(2005e1; R 2011) Standard Specification for Asphalt-Saturated Organic Felt Underlayment Used in Steep Slope Roofing
ASTM D522	(1993a; R 2008) Mandrel Bend Test of Attached Organic Coatings
ASTM D523	(2014) Standard Test Method for Specular Gloss
ASTM D5894	(2010) Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)
ASTM D610	(2008) Evaluating Degree of Rusting on Painted Steel Surfaces
ASTM D714	(2002; R 2009) Evaluating Degree of Blistering of Paints
ASTM D822	(2001; R 2006) Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
ASTM D968	(2005; R 2010) Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM E1592	(2005; R 2012) Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference
ASTM E2140	(2005; R 2012) Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference

ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G152	(2013) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G153	(2013) Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

FM GLOBAL (FM)

FM 4471	(2010) Class I Panel Roofs

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils

METAL BUILDING MANUFACTURERS ASSOCIATION (MBMA)

MBMA RSDM	(2000) Metal Roofing Systems Design Manual

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA 0409	(2006) Architectural Sheet Metal and Metal Roofing Manual
NRCA RoofMan	(2012) The NRCA Roofing Manual

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

UNDERWRITERS LABORATORIES (UL)

UL 580	(2006; Reprint Jul 2009) Tests for Uplift Resistance of Roof Assemblies
UL Bld Mat Dir	(2012) Building Materials Directory

1.2 DESCRIPTION OF METAL ROOF SYSTEM

1.2.1 Performance Requirements

Contract drawings indicate the design loads and the extent and general assembly details of the metal roofing and siding. Members and connections not indicated on the drawings shall be designed by the Contractor. Roofing and siding panels, components, transitions, and assemblies shall be the products of the same manufacturer. Roofing and siding will be designed to provide the minimum section properties shown. Steel covering shall be designed in accordance with AISI SG-673. However, such approval will not relieve the Contractor from the responsibility for coordination with other portions of the work or from any other responsibility under the contract.

Steel panels and accessory components must conform to the following standards:

ASTM A1008/A1008M
ASTM A123/A123M
ASTM A36/A36M
ASTM A463/A463M for aluminum coated steel sheet
ASTM A755/A755M for metallic coated steel sheet for exterior coil prepainted applications.
ASTM A924/A924M for metallic coated steel sheet
ASTM D522 for applied coatings
UL Bld Mat Dir

1.2.1.1 Hydrostatic Head Resistance

No water penetration when tested according to ASTM E2140. Submit leakage test report upon completion of installation.

1.2.1.2 Wind Uplift Resistance

Provide metal roof panel system that conform to the requirements of ASTM E1592 and UL 580. Uplift force due to wind action governs the design for panels. Submit wind uplift test report prior to commencing installation.

Roof system and attachments must resist the wind loads as determined by ASCE 7, in pounds per square foot. Metal roof panels and component materials must also comply with the requirements in FM 4471 as part of a panel roofing system as listed in Factory Mutual Guide (FMG) "Approval Guide" for class 1 or noncombustible construction, as applicable. Identify all materials with FMG markings.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

SD-03 Product Data

Roof panels
Accessories
Underlayments; G
Coil Stock; G
Warranty

SD-06 Test Reports

Leakage Test Report; G
Wind Uplift Test Report; G

SD-07 Certificates

Roofing Panels; G
Coil stock compatibility
Qualification of Manufacturer; G
Qualification of Applicator

SD-08 Manufacturer's Instructions

INSTALLATION MANUAL

SD-11 Closeout Submittals

Warranties
Information Card

1.4 QUALITY ASSURANCE

1.4.1 Qualification of Manufacturer

Submit documentation verifying metal roof panel manufacturer has been in the business of manufacturing metal roof panels for a period of not less than 5 years.

Manufacturer must also provide engineering services by an authorized engineer, currently licensed in the geographic area of the project, with a minimum of five (5) years experience as an engineer knowledgeable in roof wind design analysis, protocols and procedures for MBMA RSDM, ASCE 7, UL 580, and FM 4471. Engineer must provide certified engineering calculations for the project conforming to the stated references.

1.4.1.1 Single Source

Certify that roofing panels, clips, closures, and other accessories are standard products of the same manufacturer, and the most recent design of the manufacturer to operate as a complete system for the intended use.

1.4.2 Qualification of Applicator

Metal roof system applicator must be approved, authorized, or licensed in writing by the roof panel manufacturer and have a minimum of three years experience as an approved, authorized, or licensed applicator with that manufacturer, approved at a level capable of providing the specified warranty. Supply the names, locations and client contact information of 5 projects of similar size and scope constructed by applicator using the manufacturer's roofing products submitted for this project within the previous three years.

1.4.3 Field Verification

Prior to the preparation of drawings and fabrication, verify location of roof framing, roof openings and penetrations, and any other special conditions. Indicate all special conditions and measurements on final shop drawings.

1.4.4 Qualifications for Welding Work

Welding procedures must conform to AWS D1.1/D1.1Mfor steel or AWS D1.2/D1.2M for aluminum.

Operators are permitted to make only those types of weldments for which each is specifically qualified.

1.4.5 Pre-roofing Conference

After approval of submittals and before performing roofing system installation work, hold a pre-roofing conference to review the following:

a. Drawings, specifications, and submittals related to the roof work. Submit, as a minimum, technical data on coil stock and coil stock compatibility, manufacturer's installation manual, and drawings consisting of catalog cuts, design and erection drawings, shop coating and finishing specifications, and other data as necessary to clearly describe design, materials, sizes, layouts, construction details, fasteners, and erection. Drawings shall be accompanied by engineering design calculations for the structural properties of roofing and siding units.

b. Roof system components installation;

c. Procedure for the roof manufacturer's technical representative's onsite inspection and acceptance of the roofing substrate, the name of the manufacturer's technical representatives, the frequency of the onsite visits, distribution of copies of the inspection reports from the manufacturer's technical representative;

d. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing; and

e. Quality control plan for the roof system installation;

f. Safety requirements.

Coordinate pre-roofing conference scheduling with the Contracting Officer. Attendance is mandatory for the Contractor, the Contracting Officer's designated personnel, personnel directly responsible for the installation of metal roof system, flashing and sheet metal work, mechanical and electrical work, and other trades interfacing with the roof work, and representative of the metal roofing manufacturer. Before beginning roofing work, provide a copy of meeting notes and action items to all attending parties. Note action items requiring resolution prior to start of roof work.

1.5 DELIVERY, HANDLING, AND STORAGE

Deliver, store, and handle panel materials, bulk roofing products, accessories, and other manufactured items in a manner to prevent damage and deformation, as recommended by the manufacturer, and as specified.

1.5.1 Delivery

Package and deliver materials to the site in undamaged condition. Provide adequate packaging to protect materials during shipment. Do not uncrate materials until ready for use, except for inspection. Immediately upon arrival of materials at jobsite, inspect materials for damage, deformation, dampness, and staining. Remove affected materials from the site and immediately replace. Remove moisture from wet materials not otherwise affected, restack and protect from further moisture exposure.

1.5.2 Handling

Handle materials in a manner to avoid damage. Select and operate material handling equipment so as not to damage materials or applied roofing.

1.5.3 Storage

Stack materials stored on site on platforms or pallets, and cover with tarpaulins or other weathertight covering which prevents trapping of water or condensation under the covering. Store roof panels so that water which may have accumulated during transit or storage will drain off. Do not store panels in contact with materials that might cause staining. Secure coverings and stored items to protect from wind displacement.

1.6 PROJECT CONDITIONS

Weather Limitations: Proceed with installation only when existing and forecast weather conditions permit metal roof panel work to be performed according to manufacturer's written instructions and warranty requirements, and specified safety requirements.

1.7 FABRICATION

Fabricate and finish metal roof panels and accessories on a leased or installer owned portable rolling mill to the greatest extent possible, per manufacturer's standard procedures and processes, and as necessary to fulfill indicated performance requirements. Comply with indicated profiles, dimensional and structural requirements.

Provide panel profile, as indicated on drawings including major ribs and intermediate stiffening ribs for full length of panel. Fabricate panel side laps with factory installed captive gaskets or separator strips providing a weather tight seal and preventing metal-to metal contact, and minimizing noise from movements within the panel assembly.

1.7.1 Finishes

Finish quality and application processes must conform to the related standards specified within this section. Noticeable variations within the same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved samples and are assembled or installed to minimize any contrasting variations.

1.7.2 Accessories

Fabricate flashing and trim to comply with recommendations in SMACNA 1793 as applicable to the design, dimensions, metal, and other characteristics of the item indicated.

a. Form exposed sheet metal accessories which are free from excessive oil canning, buckling, and tool marks, and are true to line and levels indicated, with exposed edges folded back to form hems.

b. End Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

c. Sealed Joints: Form non-expansion, but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA 1793.

d. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

e. Fabricate cleats and attachments devices of size and metal thickness recommended by SMACNA or by metal roof panel manufacturer for application, but not less than the thickness of the metal being secured.

1.8 WARRANTIES

Provide metal roof system material and workmanship warranties meeting specified requirements. Provide revision or amendment to manufacturer's standard warranty as required to comply with the specified requirements.

1.8.1 Metal Roof Panel Manufacturer Warranty

Furnish the metal roof panel manufacturer's 10-year no dollar limit roof system materials and installation workmanship warranty, including flashing, components, trim, and accessories necessary for a watertight roof system construction. Make warranty directly to the Government, commencing at time of Government's acceptance of the roof work. The warranty must state that:

a. If within the warranty period, the metal roof system, as installed for its intended use in the normal climatic and environmental conditions of the facility, becomes non-watertight, shows evidence of moisture intrusion within the assembly, displaces, corrodes, perforates, separates at the seams, or shows evidence of excessive weathering due to defective materials or installation workmanship, the repair or replacement of the defective and damaged materials of the metal roof system and correction of defective workmanship is the responsibility of the metal roof panel manufacturer. All costs associated with the repair or replacement work are the responsibility of the metal roof panel manufacturer.

b. If the manufacturer or his approved applicator fail to perform the repairs within 72 hours of notification, emergency temporary repairs performed by others does not void the warranty.

1.8.2 Manufacturer's Finish Warranty

Provide a manufacturer's no-dollar-limit 20 year warranty for the roofing system. Issue the warranty directly to the Government at the date of Government acceptance warranting that the factory color finish, under normal atmospheric conditions at the site, will not crack, peel, or delaminate; chalk in excess of a numerical rating of 8 when measured in accordance with ASTM D4214; or fade or change colors in excess of 5 NBS units as measured in accordance with ASTM D2244.

1.8.3 Metal Roof System Installer Warranty

Provide the "Contractors 10 Year No Penal Sum Warranty for Non-Structural Metal Roof System" attached at the end of this section.

1.8.4 Continuance of Warranty

Repair or replacement work that becomes necessary within the warranty period must be approved, as required, and accomplished in a manner so as to restore the integrity of the roof system assembly and validity of the metal roof system manufacturer warranty for the remainder of the manufacturer warranty period.

1.9 CONFORMANCE AND COMPATIBILITY

The entire metal roofing and flashing system must be in accordance with specified and indicated requirements, including wind resistance requirements. Work not specifically addressed and any deviation from specified requirements must be in general accordance with recommendations of the MBMA RSDM, NRCA RoofMan, the metal panel manufacturer's published recommendations and details, and compatible with surrounding components and construction. Submit any deviation from specified or indicated requirements to the Contracting Officer for approval prior to installation.

1.10 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of English unit measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

PRODUCTS	ENGLISH UNITS	METRIC UNITS
a. Sheet Aluminum	0.040 inch	1.0 mm
b. Panels	12 inches	300 mm
- vertical legs	2 inches	50 mm
- stiffening ribs	4 inches	100 mm
c. Screws	No. 14	0.242 mm
	No. 12	0.216 mm
d. Bolts	1/4 inch	6 mm
e. Studs	3/16 inch	5 mm
f. Fasteners	1/2 inch	13 mm
	One inch	25 mm
g. Rivets	1/16 inch	5 mm
	1/8 inch	3 mm

PART 2 PRODUCTS

2.1 ROOF PANELS

Submit manufacturer's catalog data for roof panels.

2.1.1 Steel Sheet Panels

Roll-form steel sheet roof panels to the specified profile, with fy = 40 ksi, 24 gauge and depth as indicated.
Material must be plumb and true, and within the tolerances listed:

a. Galvanized steel sheet conforming to ASTM A653/A653M and AISI SG03-3 or KS D 3506.

c. Individual panels to have continuous length sufficient to cover the entire length of any unbroken roof slope with no joints or seams and formed without warping, waviness, or ripples that are not a part of the panel profile and free from damage to the finish coating system.

d. Provide panels with thermal expansion and contraction consistent with the type of system specified, and profile to custom, as indicated on contract drawings.

2.2 FACTORY FINISH AND COLOR PERFORMANCE REQUIREMENTS

All panels are to receive a factory applied polyvinylidene fluoride finish consisting of a baked topcoat with a manufacturer's recommended prime coat conforming to the following:

a. Metal Preparation: All metal is to have the surfaces carefully prepared for painting on a continuous process coil coating line by alkali cleaning, hot water rinsing, application of chemical conversion coating, cold water rinsing, sealing with an acid rinse, and thorough drying.

b. Prime Coating: A base coat of epoxy paint, specifically formulated to interact with the top-coat, is to be applied to the prepared surfaces by roll coating to a dry film thickness of 0.20 plus 0.05 mils. The prime coat must be oven cured prior to application of the finish coat.

c. Exterior Finish Coating: Apply the exterior finish coating over the primer by roll coating to a dry film thickness of 0.80 plus 0.05 mils (3.80 plus 0.05 mils for Vinyl Plastisol) for a total dry film thickness of 1.00 plus 0.10 mils (4.00 plus 0.10 mils for Vinyl Plastisol). This exterior finish coat must be oven-cured.

d. Interior finish coating: Apply a wash coat on the reverse side over primer by roll coating to a dry film thickness of 0.30 plus 0.05 mils for a total dry fill thickness of 0.50 plus 0.10 mils. The wash coat must be oven cured.

e. Color: The exterior finish chosen from the manufacturer's standard color chart.

f. Physical Properties: Coating must conform to the industry and manufacturer's standard performance criteria as listed by the following certified test reports:

General:	ASTM D5894 and ASTM D4587
Abrasion:	ASTM D968
Adhesion:	ASTM D3359
Chalking:	ASTM D4214
Chemical Pollution:	ASTM D1308
Color Change and Conformity:	ASTM D2244
Creepage:	ASTM D1654
Cyclic Corrosion Test:	ASTM D5894
Flame Spread:	ASTM E84
Flexibility:	ASTM D522
Formability:	ASTM D522
Gloss at 60 and 85 degrees:	ASTM D523
Humidity:	ASTM D2247 and ASTM D714
Oxidation:	ASTM D610
Pencil Hardness:	ASTM D3363
Reverse Impact:	ASTM D2794
Salt Spray:	ASTM B117
Weatherometer:	ASTM G152, ASTM G153 and ASTM D822

2.2.1 Specular Gloss

Finished roof surfaces to have a specular gloss value of 30 plus or minus 5 at an angle of 60 degrees when measured in accordance with ASTM D523, unless otherwise indicated.

2.3 MISCELLANEOUS METAL FRAMING

2.3.1 General

Provide cold formed metallic-coated steel sheet conforming to ASTM A653/A653M, AISI S100 or KS D 3506.

2.3.2 Fasteners and Miscellaneous Metal Framing

Provide compatible type, corrosion resistant, of sufficient size and length to penetrate the supporting element a minimum of one inch with other required properties to fasten miscellaneous metal framing members to substrates in accordance with the roof panel manufacturer's and ASCE 7 requirements.

2.3.2.1 Exposed Fasteners

Fasteners for roof panels must be corrosion resistant coated steel, compatible with the sheet panel or flashing material and of the type and size recommended by the manufacturer to meet the performance requirements and design loads. Fasteners for accessories must be the manufacturer's standard. Provide an integral metal washer, matching the color of attached material with compressible sealing EPDM gasket approximately 3/32 inch thick for exposed fasteners.

2.3.2.2 Screws

Provide corrosion resistant screws, coated steel of the type and size recommended by the manufacturer to meet the performance requirements.

2.3.2.3 Rivets

Provide closed-end type rivets, corrosion resistant coated steel where watertight connections are required.

2.3.2.4 Attachment Clips

Provide hot-dip galvanized, conforming to ASTM A653/A653M, clips. Size, shape, thickness and capacity must meet the thickness and design load criteria specified.

2.3.3 Electrodes for Manual, Shielded Metal Arc Welding

Electrodes for manual, shielded metal arc welding must meet the requirements of AWS D1.1/D1.1M, and be covered, mild-steel electrodes conforming to AWS A5.1/A5.1M.

2.4 ACCESSORIES

Accessories must be compatible with the metal roof panels. Sheet metal flashing, trim, metal closure strips, caps, and similar metal accessories must be not less than the minimum thicknesses specified for roof panels. Provide exposed metal accessories to match the panels furnished. Molded foam rib, ridge and other closure strips must be closed-cell or solid-cell synthetic rubber or neoprene premolded to match configuration of the panels and not absorb or retain water.

2.4.1 Pre-manufactured Accessories

Pre-manufactured accessories must be manufacturer's standard for intended purpose, compatible with the metal roof system and approved for use by the metal roof panel manufacturer. Construct curbs to match roof slope.

2.4.2 Metal Closure Strips

Provide factory fabricated steel closure strips of the same gauge, thickness, color, finish and profile as the specified roof panel.

2.4.3 Rubber Closure Strips

Provide closed-cell, expanded cellular rubber closure strips conforming to ASTM D1056 and ASTM D1667, extruded or molded to the configuration of the specified roof panel profile and in lengths supplied by roof panel manufacturer.

2.5 JOINT SEALANTS

2.5.1 Sealants

Sealants are to be an approved gun type for use in hand or air pressure caulking guns at temperatures above 4 degrees C (40 degrees F) (or frost-free application at temperatures above minus 12 degrees C (10 degrees F)) with a minimum solid content of 85 percent of the total volume. Sealant must dry with a tough, durable surface skin which permits it to remain soft and pliable underneath, providing a weather tight joint. No migratory staining, in conformance with to ASTM C792, is permitted on painted or unpainted metal, stone, glass, vinyl or wood.

Prime all joints to receive sealants with a compatible one-component or two-component primer as recommended by the roof panel manufacturer.

2.5.1.1 Shop Applied Sealants

Sealant for shop-applied caulking must be an approved gun grade, non-sag one-component polysulfide or silicone conforming to ASTM C792 and ASTM C920, Type II, with a curing time which ensures the sealants plasticity at the time of field erection. Color to match panel color.

2.5.1.2 Field Applied Sealants

Sealants for field-applied caulking must be an approved gun grade, non-sag on-component polysulfide or two component polyurethane with an initial maximum Shore A durometer hardness of 25, conforming to ASTM C920, Type II. Color to match panel color.

2.5.1.3 Tape Sealants

Provide pressure sensitive, 100 percent solid tape sealant with a release paper backing; permanently elastic, non-sagging, non-toxic and non-staining as approved by the roof panel manufacturer.

2.5.2 Sheet Metal Flashing and Trim

2.5.2.1 Fabrication, General

Custom fabricate sheet metal flashing and trim to comply with recommendations within the SMACNA 1793 that apply to design, dimensions, metal type, and other characteristics of design indicated. Shop fabricate items to the greatest extent possible. Obtain and verify field measurements for accurate fit prior to shop fabrication. Fabricate flashing and trim without excessive oil canning, buckling, and tool marks, true to line and levels indicated, with exposed edges folded back to form hems.

2.5.2.2 Roof Drainage Sheet Metal Fabrications

Gutters: Fabricate to cross section indicated, with riveted and soldered joints, complete with end pieces, outlet tubes, and other special accessories as required. Fabricate in minimum 244 cm (96 inch) long sections. Fabricate expansion joints and accessories from the same metal as gutters, unless otherwise indicated.

Downspouts: Fabricate circular, rectangular, or square downspouts as designed complete with mitered elbows. Furnish with metal hangars of same material as downspouts and anchors.

2.6 INSULATION

Insulation, facer material and attachment must be compatible with metal roof system specified, as approved by the roof panel manufacturer, and conform to ASTM C552 (cellular glass) or ASTM C553 (fiber blankets).

2.6.1 Fire Rated Assembly System

Provide semi-rigid glass-fiber insulation board conforming to ASTM C553, Form A, Class 1, Class A fire-hazard classification with a minimum density of 24.8 kilogram per cubic meter and 38 millimeter (1.55 pounds per cubic foot (pcf) and 1-1/2 inches) thick. Thermal conductivity (K) must not exceed 0.42 watt per meter per degree K (0.24).

2.6.2 Fire Rated Roof Panel Assembly

Provide materials for fire-rated roof panel construction as follows:

Impaling clips, accessories, and fasteners must be UL listed 40 U18.24 UL Bld Mat Dir galvanized steel sheet or impaling bolts welded to each wall unit joint and spaced not more than 1200 millimeter (48 inches) on center.

Provide bar subgirts 38 by 3 millimeter (1-1/2 by 1/8 inch) galvanized steel with slotted holes for welding to end of impaling clip spikes.

Provide galvanized steel structural angles and flashing angles, gage or thickness as indicated, or material as specified. Flashing angles must be not less than 1.3 millimeter thick (No. 18 U.S. standard gage).

Submit fire rating test report to contracting officer for review and approval. Secure written approval prior to commencement of installation.

2.7 UNDERLAYMENTS

Provide one of the following types underlayments, as indicated on contract drawings.

2.7.1 Felt Underlayment

Provide No. 30 asphalt-saturated organic , non-perforated felt underlayment in compliance with ASTM D226/D226M, Type II, or ASTM D4869/D4869M.

2.7.2 Self-Adhering Modified Bitumen Underlayment

Provide self-adhering modified bitumen membrane underlayment material in compliance with ASTM D1970/D1970M, suitable for use as underlayment for metal roofing. Use membrane resistant to cyclical elevated temperatures for extended period of time in high heat service conditions. Provide membrane with integral non-tacking top surface of polyethylene film or other surface material to serve as separator between bituminous material and metal products to be applied above.

2.7.3 EPDM Membrane

Ethylene Propylene Diene Terpolymer (EPDM), ASTM D4637/D4637M, Type I, non-reinforced, minimum 1.1 mm (0.045 inch) thick.

2.7.4 Slip Sheet

Provide 0.24 kg per square meter (5 pounds per 100 sf) rosin sized unsaturated building paper for slip sheet.

2.8 GASKETS AND SEALING/INSULATING COMPOUNDS

Gaskets and sealing/insulating compounds must be nonabsorptive and suitable for insulating contact points of incompatible materials. Sealing/insulating compounds must be non-running after drying.

2.9 FINISH REPAIR MATERIAL

Repair paint for color finish enameled roofing must be compatible paint of the same formula and color as the specified finish furnished by the manufacturer.

2.10 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances, metal roof panel supports, and other conditions affecting performance of the work. Ensure surfaces are suitable, dry and free of defects and projections which might affect the installation.

Examine primary and secondary roof framing to verify that rafters, purlins, angels, channels, and other structural support members for panels and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer, UL, ASTM, and ASCE 7 and applicable seismic requirements.

Examine solid roof sheathing to verify that sheathing joints are supported by framing or blocking; and that installation is within flatness tolerances required by metal roof panel manufacturer.

Examine rough-in for components and systems penetrating metal roof panels to verify actual locations of penetrations relative to seam locations of panels prior to installation.

Submit a written report to the Contracting Officer, endorsed by the installer, listing conditions detrimental to the performance of the work. Proceed with installation only after defects have been corrected.

3.2 INSTALLATION

Installation must meet specified requirements and be in accordance with the manufacturer's installation instructions and approved shop drawings. Do not install damaged materials. Dissimilar materials which are not compatible when contacting each other must be insulated by means of gaskets or sealing/insulating compounds. Keep all exposed surfaces and edges clean and free from sealant, metal cuttings, hazardous burrs, and other foreign material. Remove stained, discolored, or damaged materials from the site.

3.2.1 Preparation

Clean all substrate substances which may be harmful to insulation and roof panels including removing projections capable of interfering with with insulation and roof panel attachment.

Install sub-purlins, eave angles, furring, and other miscellaneous roof panel support members and anchorage according to metal roof panel manufacturer's written instructions.

3.2.2 Underlayment

Install underlayment according to roof panel manufacturer's written recommendations and recommendation in NRCA "The NRCA Roofing and Waterproofing Manual".

3.2.2.1 Single Layer Felt Underlayment for a Standard Slope Roof Deck

Install single layer of felt underlayment on roof deck perpendicular to roof slope in parallel courses. Lap sides a minimum of 5.1 cm (2 inches) over underlying course. Lap ends a minimum of 10.2 cm (4 inches). Stagger end laps between succeeding courses a minimum of 183 cm (72 inches). Fasten with felt underlayment roofing nails.

Install felt underlayment on roof deck not covered by self-adhering sheet underlayment. Lap sides of felt over self-adhering sheet underlayment not less than 7.62 cm (3 inches) in a direction to shed water. Lap ends of felt not less than 15.3 cm (6 inches) over self-adhering sheet underlayment.

3.2.2.2 Self-Adhering Sheet Underlayment

Install self-adhering sheet underlayment; wrinkle free on roof deck. Comply with low-temperature installation restrictions of manufacturer where applicable. Install at locations indicated on project drawings, lapped in a direction to shed water. Lap sides not less than 8.9 cm (3-1/2 inches). Lap ends not less than 15.3 cm (6 inches) staggered 61 cm (24 inches) between courses. Roll laps with roller. Cover underlayment within seven days.

3.2.2.3 Slip Sheet

Apply specified slip sheet at time of roof panel installation when felt or other underlayment is used that may be in direct contact with and adhere to or adversely impact the underside of roof panels, and as otherwise recommended by the roof panel manufacturer.

3.3 INSULATION INSTALLATION

Install insulation concurrently with metal roof panel installation, in thickness indicated, to cover entire roof, according to manufacturer's written instructions.

3.4 PROTECTION OF APPLIED MATERIALS

Do not permit storing, walking, wheeling, and trucking directly on applied roofing/insulation materials. Provide temporary walkways, runways, and platforms of smooth clean boards or planks as necessary to avoid damage to applied roofing/insulation materials, and to distribute weight to conform to indicated live load limits of roof construction.

3.5 FASTENER INSTALLATION

Anchor metal roof panels and other components of the Work securely in place, using approved fasteners according to manufacturer's written instructions.

3.5.1 Welding

Procedures for manual, shielded metal-arc welding, the appearance and quality of welds made, and the methods used in correcting welding work must be in accordance with AWS D1.1/D1.1M.

3.6 FLASHING, TRIM, AND CLOSURE INSTALLATION

3.6.1 General Requirements

Comply with performance requirements, manufacturer's written installation instructions, and SMACNA 1793. Provide concealed fasteners where possible. Set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently water tight and weather resistant. Work is to be accomplished to form weather tight construction without waves, warps, buckles, fastening stresses or distortion, and to allow for expansion and contraction. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accomplish the work must conform to the manufacturers written instructions.

3.6.2 Metal Flashing

Install exposed metal flashing at building corners, rakes, eaves, junctions between metal siding and roofing, valleys and changes off slope or direction in metal roofing, building expansion joints and gutters.

Exposed metal flashing must be the same material, color, and finish as the specified metal roofing panels. Furnish flashing in minimum 2.44 m (8 foot) lengths. Exposed flashing must have 100 mm (1 inch) locked and blind soldered end joints, with expansion joints at intervals of no greater than 4.88 m (16 feet).

Fasten flashing at not more than 200 mm (8 inches) on center for roofs, except where flashing is held in place by the same screws used to secure panels. Exposed flashing and flashing subject to rain penetration must be bedded in specified joint sealant. Flashing which is contact with dissimilar metals must be isolated by means of the specified asphalt mastic material to prevent electrolytic deterioration.

Form drips to the profile indicated, with the edge folded back 1.27 cm (1/2 inch) to form a reinforced drip edge.

3.7 ROOF PANEL INSTALLATION

Provide metal roof panels of full length from eave to ridge or eave to wall as indicated, unless otherwise indicated or restricted by shipping limitations. Anchor metal roof panels or other components of the Work securely in place, with provisions for thermal and structural movement in accordance with NRCA 0409.

Steel Roof Panels: Use stainless steel fasteners for exterior surfaces and galvanized fasteners for unexposed surfaces.

Anchor Clips: Anchor metal roof panels and other components of the Work securely in place, using approved fasteners according to manufacturer's written instructions. Provide all blocking and nailers as required.

Metal Protection: Where dissimilar metals contact each other or possibly corrosive substrates, protect against galvanic action by coating contact surfaces with a bituminous coating or applying rubberized asphalt underlayment to each contact surface.

Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and required for weatherproof performance of metal roof panel system. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal roof panel manufacturer.

3.7.1 Handling and Erection

Erect roofing system in accordance with the approved erection drawings, printed instructions and safety precautions of the manufacturer.

Do not subject panels to overloading, abuse, or undue impact. Do not apply bent, chipped, or defective panels. Damaged panels must be replaced and removed from the site at the contractor's expense. Erect panels true, plumb, and in exact alignment with the horizontal and vertical edges of the building, securely anchored, and with indicated rake, eave, and curb overhang. Allow for thermal movement of the roofing, movement of the building structure, and provide permanent freedom from noise due to wind pressure.

Do not permit storage, walking, wheeling or trucking directly on applied roofing materials. Provide temporary walkways, runways, and platforms of smooth clean boards or planks as necessary to avoid damage to the installed roofing materials, and to distribute weight to conform to the indicated live load limits of the roof construction.

Roof panels must be laid with corrugations in the direction of the roof slope. End laps of exterior roofing must not be less than 20.3 cm (8 inches); side laps of standard exterior corrugated panels must not be less than 2-1/2 corrugations.

Field cutting of metal roof panels by torch is not permitted. Field cut only as recommended by manufacturer's written instructions.

3.7.2 Closure Strips

Install metal closure strips at open ends of metal ridge rolls; open ends of corrugated or ribbed pattern roofs, and at intersection of wall and roof, unless open ends are concealed with formed eave flashing; rake of metal roof unless open end has a formed flashing member; and in other required areas.

Install closure strips at intersection of the wall with metal roofing; top and bottom of metal siding; heads of wall openings; and in other required locations.

3.7.3 Workmanship

Make lines, arises, and angles sharp and true. Free exposed surfaces from any visible wave, warp, buckle and tool marks. Fold back exposed edges neatly to form a 1.27 cm (1/2 inch) hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections which might affect the application. For installation of items not shown in detail or not covered by specifications conform to the applicable requirements of SMACNA 1793. Provide sheet metal flashing in the angles formed where roof decks abut walls, curbs, ventilators, pipes, or other vertical surfaces and wherever indicated and as necessary to make the work watertight.

3.8 ACCEPTANCE PROVISIONS

3.8.1 Erection Tolerances

Erect metal roofing straight and true with plumb vertical lines correctly lapped and secured in accordance with the manufacturer's written instructions. Horizontal lines must not vary more than .32 cm in 12.2 m (1/8 inch in 40 feet).

3.8.2 Leakage Tests

Finished application of metal roofing is to be subject to inspection and test for leakage by the Contracting Officer or his designated representative, and Architect/Engineer. Inspection and tests will be conducted without cost to the Government.

Inspection and testing is to be made promptly after erection to permit correction of defects and removal/replacement of defective materials.

3.8.3 Repairs to Finish

Scratches, abrasions, and minor surface defects of finish may be repaired with the specified repair materials and as recommended by the metal roof panel manufacturer. Finished repaired surfaces must be uniform and free from variations of color and surface texture. Repaired metal surfaces that are not acceptable to the project requirements are to be immediately removed and replaced with new material.

3.8.4 Paint Finished Metal Roofing

Paint finished metal roofing will be tested for color stability by the

Contracting Officer during the manufacturer's specified guarantee period. Panels that indicate color changes, fading, or surface degradation, determined by visual examination, must be removed and replaced with new panels at no expense to the Government. New panels will be subject to the specified tests for an additional year from the date of their installation.

3.9 CLEAN UP AND DISPOSAL

Clean exposed sheet metal work at completion of installation. Remove metal shavings, filings, nails, bolts, and wires from roofs. Remove grease and oil films, excess sealants, handling marks, contamination from steel wool, fittings and drilling debris and scrub the work clean. Exposed metal surfaces must be free of dents, creases, waves, scratch marks, solder or weld marks, and damage to the finish coating. Touch up scratches in panel finish with manufacturer supplied touch-up paint system to match panel finish. Treat exposed cut edges with manufacturer supplied clear coat.

Collect all scrap/waste materials and place in containers. Promptly dispose of demolished and scrap materials. Do not allow scrap/waste materials to accumulate on-site; transport immediately from the government property and legally dispose of them.

3.10 INFORMATION CARD

For each roof, furnish one digital copy (.pdf - text searchable)of an information card for facility records and one hard copy card laminated in plastic and framed for interior display at roof access point, or a photoengraved 1 mm (0.032 inch) thick aluminum card for exterior display.

Make hard copy of card 215 mm by 275 mm (8 1/2 by 11 inches) minimum. Information card must identify facility name and number; location; contract number; approximate roof area; detailed roof system description, including deck type, roof panel manufacturer and product name, type underlayment(s), date of completion; installing contractor identification and contact information; manufacturer warranty expiration, warranty reference number, and contact information. Install card at interior roof top access point and provide a paper copy to the Contracting Officer.

3.11 WARRANTY

CONTRACTOR'S WARRANTY TEN (10) YEAR NO PENAL SUM

FOR

NON-STRUCTURAL METAL ROOF SYSTEM

FACILITY DESCRIPTION____

BUILDING NUMBER:____

CORPS OF ENGINEERS CONTRACT NUMBER:_________________________________

CONTRACTOR

CONTRACTOR:____

ADDRESS:____

POINT OF CONTACT:____

TELEPHONE NUMBER:____

OWNER

OWNER:____

ADDRESS:____

POINT OF CONTACT:____

TELEPHONE NUMBER:____

CONSTRUCTION AGENT

CONSTRUCTION AGENT:____

ADDRESS:____

POINT OF CONTACT:____

TELEPHONE NUMBER:____

CONTRACTOR'S TEN (10)) YEAR NO PENAL SUM WARRANTY
FOR
NON-STRUCTURAL METAL ROOF SYSTEM
(continued)

THE NON-STRUCTURAL METAL ROOF SYSTEM INSTALLED ON THE ABOVE NAMED BUILDING IS WARRANTED BY ______________________________ FOR A PERIOD OF FIVE (5) YEARS AGAINST WORKMANSHIP AND MATERIAL DEFICIENCIES, WIND DAMAGE, STRUCTURAL FAILURE, AND LEAKAGE. THE NON-STRUCTURAL METAL ROOFING SYSTEM COVERED UNDER THIS WARRANTY SHALL INCLUDE, BUT SHALL NOT BE LIMITED TO, THE FOLLOWING: THE ENTIRE ROOFING SYSTEM, MANUFACTURER SUPPLIED FRAMING AND STRUCTURAL MEMBERS, METAL ROOF PANELS, FASTENERS, CONNECTORS, ROOF SECUREMENT COMPONENTS, AND ASSEMBLIES TESTED AND APPROVED IN ACCORDANCE WITH UL 580. IN ADDITION, THE SYSTEM PANEL FINISHES, SLIP SHEET, INSULATION, VAPOR RETARDER, ALL ACCESSORIES, COMPONENTS, AND TRIM AND ALL CONNECTIONS ARE INCLUDED. THIS INCLUDES ROOF PENETRATION ITEMS SUCH AS VENTS, CURBS, SKYLIGHTS; INTERIOR OR EXTERIOR GUTTERS AND DOWNSPOUTS; EAVES, RIDGE, HIP, VALLEY, RAKE, GABLE, WALL, OR OTHER ROOF SYSTEM FLASHING INSTALLED AND ANY OTHER COMPONENTS SPECIFIED WITHIN THIS CONTRACT TO PROVIDE A WEATHERTIGHT ROOF SYSTEM; AND ITEMS SPECIFIED IN OTHER SECTIONS OF THE SPECIFICATIONS THAT ARE PART OF THE NON-STRUCTURAL METAL ROOFING SYSTEM.

ALL MATERIAL DEFICIENCIES, WIND DAMAGE, STRUCTURAL FAILURE, AND LEAKAGE ASSOCIATED WITH THE NON-STRUCTURAL METAL ROOF SYSTEM COVERED UNDER THIS WARRANTY SHALL BE REPAIRED AS APPROVED BY THE CONTRACTING OFFICER. THIS WARRANTY SHALL COVER THE ENTIRE COST OF REPAIR OR REPLACEMENT, INCLUDING ALL MATERIAL, LABOR, AND RELATED MARKUPS. THE ABOVE REFERENCED WARRANTY COMMENCED ON THE DATE OF FINAL ACCEPTANCE ON ____________________________ AND WILL REMAIN IN EFFECT FOR STATED DURATION FROM THIS DATE.

SIGNED, DATED, AND NOTARIZED (BY COMPANY PRESIDENT)

____
(Company President) (Date)

CONTRACTOR'S TEN (10) YEAR NO PENAL SUM WARRANTY
FOR
NON-STRUCTURAL METAL ROOFING SYSTEM
(continued)

THE CONTRACTOR MUST SUPPLEMENT THIS WARRANTY WITH WRITTEN WARRANTIES FROM THE MANUFACTURER AND/OR INSTALLER OF THE NON-STRUCTURAL METAL ROOFING SYSTEM.SUBMIT ALONG WITH THE CONTRACTOR'S WARRANTY. HOWEVER, THE CONTRACTOR IS ULTIMATELY RESPONSIBLE FOR THIS WARRANTY AS OUTLINED IN THE SPECIFICATIONS AND AS INDICATED IN THIS WARRANTY EXAMPLE.

EXCLUSIONS FROM COVERAGE

1. NATURAL DISASTERS, ACTS OF GOD (LIGHTNING, FIRE, EXPLOSIONS, SUSTAINED WIND FORCES IN EXCESS OF THE DESIGN CRITERIA, EARTHQUAKES, AND HAIL).

2. ACTS OF NEGLIGENCE OR ABUSE OR MISUSE BY GOVERNMENT OR OTHER PERSONNEL, INCLUDING ACCIDENTS, VANDALISM, CIVIL DISOBEDIENCE, WAR, OR DAMAGE CAUSED BY FALLING OBJECTS.

3. DAMAGE BY STRUCTURAL FAILURE, SETTLEMENT, MOVEMENT, DISTORTION, WARPAGE, OR DISPLACEMENT OF THE BUILDING STRUCTURE OR ALTERATIONS MADE TO THE BUILDING.

4. CORROSION CAUSED BY EXPOSURE TO CORROSIVE CHEMICALS, ASH OR FUMES GENERATED OR RELEASED INSIDE OR OUTSIDE THE BUILDING FROM CHEMICAL PLANTS, FOUNDRIES, PLATING WORKS, KILNS, FERTILIZER FACTORIES, PAPER PLANTS, AND THE LIKE.

5. FAILURE OF ANY PART OF THE NON-STRUCTURAL METAL ROOF DUE TO ACTIONS BY THE OWNER TO INHIBIT FREE DRAINAGE OF WATER FROM THE ROOF AND GUTTERS AND DOWNSPOUTS OR ALLOW PONDING WATER TO COLLECT ON THE ROOF SURFACE. CONTRACTOR'S DESIGN MUST INSURE FREE DRAINAGE FROM THE ROOF AND NOT ALLOW PONDING WATER.

6. THIS WARRANTY APPLIES TO THE NON-STRUCTURAL METAL ROOFING SYSTEM. IT DOES NOT INCLUDE ANY CONSEQUENTIAL DAMAGE TO THE BUILDING INTERIOR OR CONTENTS WHICH IS COVERED BY THE WARRANTY OF CONSTRUCTION CLAUSE INCLUDED IN THIS CONTRACT.

7. THIS WARRANTY CANNOT BE TRANSFERRED TO ANOTHER OWNER WITHOUT WRITTEN CONSENT OF THE CONTRACTOR; AND THIS WARRANTY AND THE CONTRACT PROVISIONS WILL TAKE PRECEDENCE OVER ANY CONFLICTS WITH STATE STATUTES.

CONTRACTOR'S TEN (10) YEAR NO PENAL SUM WARRANTY
FOR
NON-STRUCTURAL METAL ROOF SYSTEM
(continued)

**REPORTS OF LEAKS AND ROOF SYSTEM DEFICIENCIES MUST BE RESPONDED TO WITHIN 48 HOURS OF RECEIPT OF NOTICE, BY TELEPHONE OR IN WRITING, FROM EITHER THE OWNER OR CONTRACTING OFFICER. INITIATE EMERGENCY REPAIRS TO PREVENT FURTHER ROOF LEAKS IMMEDIATELY; SUBMIT A WRITTEN PLAN FOR APPROVAL TO REPAIR OR REPLACE THIS ROOF SYSTEM WITHIN SEVEN (7) CALENDAR DAYS. COMMENCE ACTUAL WORK FOR PERMANENT REPAIRS OR REPLACEMENT WITHIN 30 DAYS AFTER RECEIPT OF NOTICE, AND COMPLETED WITHIN A REASONABLE TIME FRAME. IF THE CONTRACTOR FAILS TO ADEQUATELY RESPOND TO THE WARRANTY PROVISIONS, AS STATED IN THE CONTRACT AND AS CONTAINED HEREIN, THE CONTRACTING OFFICER MAY HAVE THE NON-STRUCTURAL METAL ROOF SYSTEM REPAIRED OR REPLACED BY OTHERS AND CHARGE THE COST TO THE CONTRACTOR.

IN THE EVENT THE CONTRACTOR DISPUTES THE EXISTENCE OF A WARRANTABLE DEFECT, THE CONTRACTOR MAY CHALLENGE THE OWNER'S DEMAND FOR REPAIRS AND/OR REPLACEMENT DIRECTED BY THE OWNER OR CONTRACTING OFFICER EITHER BY REQUESTING A CONTRACTING OFFICER'S DECISION UNDER THE CONTRACT DISPUTES ACT, OR BY REQUESTING THAT AN ARBITRATOR RESOLVE THE ISSUE. THE REQUEST FOR AN ARBITRATOR MUST BE MADE WITHIN 48 HOURS OF BEING NOTIFIED OF THE DISPUTED DEFECTS. UPON BEING INVOKED, THE PARTIES SHALL, WITHIN TEN (10) DAYS, JOINTLY REQUEST A LIST OF FIVE (5) ARBITRATORS FROM THE FEDERAL MEDIATION AND CONCILIATION SERVICE. THE PARTIES MUST CONFER WITHIN TEN (10) DAYS AFTER RECEIPT OF THE LIST TO SEEK AGREEMENT ON AN ARBITRATOR. IF THE PARTIES CANNOT AGREE ON AN ARBITRATOR, THE CONTRACTING OFFICER AND THE PRESIDENT OF THE CONTRACTOR'S COMPANY WILL STRIKE ONE (1) NAME FROM THE LIST ALTERNATIVELY UNTIL ONE (1) NAME REMAINS. THE REMAINING PERSON IS THE DULY SELECTED ARBITRATOR. THE COSTS OF THE ARBITRATION, INCLUDING THE ARBITRATOR'S FEE AND EXPENSES, COURT REPORTER, COURTROOM OR SITE SELECTED, ETC., WILL BE BORNE EQUALLY BETWEEN THE PARTIES. EITHER PARTY DESIRING A COPY OF THE TRANSCRIPT MUST PAY FOR THE TRANSCRIPT. A HEARING WILL BE HELD AS SOON AS THE PARTIES CAN MUTUALLY AGREE. A WRITTEN ARBITRATOR'S DECISION WILL BE REQUESTED NOT LATER THAN 30 DAYS FOLLOWING THE HEARING. THE DECISION OF THE ARBITRATOR WILL NOT BE BINDING; HOWEVER, IT WILL BE ADMISSIBLE IN ANY SUBSEQUENT APPEAL UNDER THE CONTRACT DISPUTES ACT.

POST A FRAMED COPY OF THIS WARRANTY IN THE MECHANICAL ROOM OR OTHER APPROVED LOCATION DURING THE ENTIRE WARRANTY PERIOD.

-- End of Section --

SECTION 07 42 13

METAL WALL PANELS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 501.1	(2005) Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure
AAMA 800	(2010) Voluntary Specifications and Test Methods for Sealants

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 341	(2010) Seismic Provisions for Structural Steel Buildings

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI S100	(2007; Supp 1: 2009; Supp 2: 2010) North American Specification for the Design of Cold-Formed Steel Structural Members
AISI SG03-3	(2002; Suppl 2001-2004; R 2008) Cold-Formed Steel Design Manual Set

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS A5.1/A5.1M	(2004) Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2008) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability,

	Solution Hardened, and Bake Hardened
ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A463/A463M	(2010) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A606/A606M	(2009a) Standard Specification for Steel Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A755/A755M	(2011) Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1308	(2002; R 2007) Effect of Household Chemicals on Clear and Pigmented Organic Finishes
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1667	(2005; R 2011) Flexible Cellular Materials - Poly (Vinyl Chloride) Foam (Closed-Cell)
ASTM D2244	(2011) Calculation of Color Tolerances and

	Color Differences from Instrumentally Measured Color Coordinates
ASTM D2247	(2011) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D2794	(1993; R 2010) Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D3359	(2009; E 2010; R 2010) Measuring Adhesion by Tape Test
ASTM D3363	(2005e1; R 2011) Film Hardness by Pencil Test
ASTM D4214	(2007) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D4587	(2011) Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings
ASTM D522	(1993a; R 2008) Mandrel Bend Test of Attached Organic Coatings
ASTM D523	(2014) Standard Test Method for Specular Gloss
ASTM D5894	(2010) Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)
ASTM D610	(2008) Evaluating Degree of Rusting on Painted Steel Surfaces
ASTM D714	(2002; R 2009) Evaluating Degree of Blistering of Paints
ASTM D822	(2001; R 2006) Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
ASTM D968	(2005; R 2010) Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM E1592	(2005; R 2012) Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference
ASTM E283	(2004) Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E331	(2000; R 2009) Water Penetration of Exterior Windows, Skylights, Doors, and

	Curtain Walls by Uniform Static Air Pressure Difference
ASTM E72	(2005) Conducting Strength Tests of Panels for Building Construction
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G152	(2013) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G153	(2013) Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils

METAL BUILDING MANUFACTURERS ASSOCIATION (MBMA)

MBMA MBSM	(2002) Metal Building Systems Manual

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM AMP 500	(2006) Metal Finishes Manual

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir	(2012) Building Materials Directory

1.2 DEFINITIONS

Metal Wall Panel: Metal wall panels, attachment system components and accessories necessary for a complete weather-tight wall system.

1.3 DESCRIPTION OF WALL PANEL SYSTEM

Contract drawings indicate the design loads and the extent and general assembly details of the metal roofing and siding. Members and connections not indicated on the drawings shall be designed by the Contractor. Roofing and siding panels, components, transitions, and assemblies shall be the products of the same manufacturer. Roofing and siding will be designed to provide the minimum section properties shown. Steel covering shall be designed in accordance with AISI SG-673. However, such approval will not relieve the Contractor from the responsibility for coordination with other portions of the work or from any other responsibility under the contract.

1.3.1 Metal Wall Panel General Performance

Comply with performance requirements, conforming to AISI S100, without failure due to defective manufacture, fabrication, installation, or other defects in construction. Wall panels and accessory components must conform to the following standards:

ASTM A1008/A1008M
ASTM A123/A123M
ASTM A36/A36M
ASTM A653/A653M
ASTM A463/A463M for aluminum coated steel sheet
ASTM A606/A606M
ASTM A755/A755M for metallic coated steel sheet for exterior coil pre-painted applications.
ASTM A780/A780M for repair of damage or uncoated areas of hot-dipped galvanized coating.
ASTM A924/A924M for metallic coated steel sheet
ASTM D522 for applied coatings
UL Bld Mat Dir

1.3.2 Structural Performance

Maximum calculated fiber stress must not exceed the allowable value in the AISI or AA manuals; a one third overstress for wind is allowed. Midspan deflection under maximum design loads is limited to L/180. Contract drawings show the design wind loads and the extent and general assembly details of the metal siding. Contractor must provide design for members and connections not shown on the drawings. Siding panels and accessories must be the products of the same manufacturer.

Provide metal wall panel assemblies complying with the load and stress requirements in accordance with ASTM E1592. Wind Load force due to wind action governs the design for panels.

Wall systems and attachments are to resist the wind loads as determined by ASTM E72 and ASCE 7 in the geographic area where the construction will take place, in pounds per square foot. Submit one hard copy & one digital copy (.pdf - text searchable) of wind load tests to the Contracting Officer.

1.3.3 Air Infiltration

Air leakage must conform to the limits through the wall assembly area when tested according to ASTM E283.

1.3.4 Water Penetration Under Static Pressure

No water penetration when tested according to ASTM E331.

1.3.5 Water Penetration Under Dynamic Pressure

No evidence of water leakage when tested according to AAMA 501.1.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office

that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Wall Panels
Sealants and Caulking

SD-05 Design Data

Wind load design analysis ; G

SD-06 Test Reports

Wind Load Tests; G

SD-07 Certificates

Qualification of Manufacturer
Qualification of Installation Contractor
Qualification of Welders
Coil Stock
Fasteners
Galvanizing Repair Paint
Enamel Repair Paint

SD-08 Manufacturer's Instructions

Installation of Wall panels; G

SD-11 Closeout Submittals

Warranty; G
Maintenance Instructions

1.5 QUALITY ASSURANCE

1.5.1 Pre-Installation Conference

Upon notification of submittal receipt and approval by the Contracting Officer; and prior to the commencement of the work, the Contractor must attend a pre-installation conference to review the following:

a. Drawings and Specifications.

b. Qualification of Installer, Qualification of Welders.

c. Approved Warranty

d. Coatings and base metal tests, chalking tests

e. Construction schedule, availability of materials, Installer's personnel, equipment and facilities required to progress with the work without delay.

f. Methods and procedures related to installation of wall panels, including manufacturer's written instructions. Include detailed application instructions and standard manufacturer drawings altered as required by these specifications. Explicitly identify in writing, differences between manufacturer's instructions and the specified requirements.

g. Support conditions for compliance with requirements, including alignment between and attachment to structural members.

h. Flashing, special siding details, wall penetrations, openings, and condition of other construction that will affect metal wall panels.

i. Governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.

j. Temporary protection requirements for metal wall panel assembly during and after installation.

k. Wall panel observation and repair procedures after metal wall panel installation. Provide detailed written instructions including copies of Material Safety Data Sheets for maintenance and repair materials, and manufacturer's maintenance instructions.

1.5.1.1 Installation Drawings

Installation shop drawings for wall panels, flashing, accessories, and anchorage systems must indicate completely dimensioned structural frame and erection layouts, openings in the wall, special framing details, and construction details at corners, building intersections and flashing, location and type of mastic and metal filler strips.

1.5.1.2 Wind Load Design Analysis

Wind design analysis must include wall plan delineating dimensions and attachment patterns for each zone. Wind design analysis must be prepared and sealed by Licensed Project Engineer in the geographic area where the construction will take place.

As applicable, submit the following wind load design analysis data, to include, but not limited to:

a. wind speed
b. exposure category,co-efficient,importance factor
c. type of facility
d. negative pressures for each zone
e. methods and requirements of attachment

1.5.2 Manufacturer's Technical Representative

The representative must have authorization from manufacturer to approve field changes and be thoroughly familiar with the products and installations in the geographical area where construction will take place.

1.5.3 Qualification of Manufacturer

Certify that metal wall panel system manufacturer has a minimum of five (5) years experience in manufacturing metal wall system and accessory products.

Manufacturer must also provide engineering services by an authorized engineer; currently licensed in the geographical area where construction will take place, having a minimum of four (4) years experience as an engineer knowledgeable in wind load design analysis, protocols and procedures per MBMA MBSM, "Metal Building Systems Manual"; ASCE 7, and ASTM E1592 and seismic design conforming to AISC 341.

Provide certified engineering calculations, using the products submitted, for Wind load requirements in accordance with ASCE 7.

1.5.3.1 Manufacturer's Certificates

Also provide the following certifications from the manufacturer:

Coil Stock
Fasteners
Galvanizing Repair Paint
Enamel Repair Paint

Submit certification from coil stock manufacturer or supplier that the machinery used will form the provided coil stock without warping, waviness, or rippling that is not a part of the panel profile, and without damage, abrasion or marring of the finish coating.

1.5.4 Certified Qualification of Installation Contractor

The installation contractor must be approved and certified by the metal wall panel manufacturer prior to beginning the installation of the metal wall panel system. Subcontracting by Certified Contractor for the metal wall panel work is not permitted.

1.5.4.1 Qualifications for Welding Work

Qualification of welders and welding must conform to AWS A5.1/A5.1M, AWS D1.1/D1.1Mfor steel or AWS D1.2/D1.2M for aluminum.

1.5.5 Single Source

Obtain each type of metal wall panels, clips, closure materials and other accessories from the standard products of the single source from a single manufacturer to operate as a complete system for the intended use.

1.5.6 Manufacturer's Maintenance Instructions

Provide manufacturer's detailed written instructions including copies of Material Safety Data Sheets for maintenance and repair materials.

1.6 DELIVERY, HANDLING, AND STORAGE

Deliver and protect package components, sheets, metal wall panels, and other manufactured items to prevent damage or deformation during transportation and handling.

Unload, store, and erect metal wall panels in a manner to prevent bending, warping, twisting, and surface damage.

Stack and store metal wall panels horizontally on platforms or pallets, covered with suitable weather-tight and ventilated covering to ensure dryness, with positive slope for drainage of water. Do not store metal wall panels in contact with other materials that might cause staining, denting, or other surface damage.

Retain strippable protective covering on metal wall panel until actual installation.

1.7 PROJECT CONDITIONS

1.7.1 Field Measurements

Verify locations of wall framing and opening dimensions by field measurements before metal wall panel fabrication and indicate measurements on Shop Drawings.

1.7.2 Weather Limitations

Proceed with installation preparation only when existing and forecasted weather conditions permit Work to proceed without water entering into wall system or building.

1.8 WARRANTY

Warranty must conform to the Sample Warranty as reviewed and approved by the Contracting Officer.

1.8.1 20 Year "No Dollar Limit" Warranty for Labor and Material

Furnish manufacturer's no-dollar-limit warranty for the metal wall panel system. The warranty period is to be no less than twenty (20) years from the date of Government acceptance of the work. The warranty is to be issued directly to the Government. The warranty is to provide that if within the warranty period the metal wall panel system shows evidence of corrosion, perforation, rupture or excess weathering due to deterioration of the wall panel system resulting from defective materials and correction of the defective workmanship is to be the responsibility of the metal wall panel system manufacturer. Repairs that become necessary because of defective materials and workmanship while metal wall panel system is under warranty are to be performed within 24 hours after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within 24 hours of notification will constitute grounds for having emergency repairs performed by others and not void the warranty.

PART 2 PRODUCTS

2.1 FABRICATION

Unless approved otherwise, fabricate and finish metal wall panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes and as necessary to fulfill indicated and specified performance requirements. Comply with indicated profiles and with dimensional and structural requirements.

Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel. Fabricate metal wall panel side laps with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will seal weather-tight and minimize noise from movements within panel assembly.

2.1.1 Sheet Metal Accessories

Fabricate flashing and trim to comply with recommendations in SMACNA 1793 that apply to the design, dimensions, metal, and other characteristics of item indicated:

a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

b. End Seams: fabricate nonmoving end seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

c. Sealed Joints: form non-expansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA 1793.

d. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

e. Fabricate cleats and attachment devices of size and metal thickness recommended by SMACNA 1793 or by metal wall panel manufacturer for application, but not less than thickness of metal being secured.

2.2 PANEL MATERIALS

2.2.1 Steel Sheet

Roll-form steel wall panels to the specified profile, with fy= 2.81 kscm (40 ksi), 24 gauge and depth as indicated. Material must be plumb and true, and within the tolerances listed:

a. Galvanized Steel Sheet conforming to ASTM A653/A653M and AISI SG03-3 or KS D 3506.

b. Individual panels must be continuous length to cover the entire length of any unbroken wall area with no joints or seams and formed without warping, waviness, or ripples that are not part of the panel profile and free of damage to the finish coating system.

c. Provide panels with thermal expansion and contraction consistent with the type of system specified, and custom profile as indicated on drawings.

2.2.2 Factory Color Finish

Comply with NAAMM AMP 500 for recommendations for applying and designating finishes. Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved samples and are assembled or installed to minimize contrast.

All panels are to receive a factory-applied polyvinylidene fluoride finish consisting of a baked-on top-coat with a manufacturer's recommended prime coat conforming to the following:

2.2.2.1 Metal Preparation

Carefully prepare all metal surfaces for painting on a continuous process coil coating line by alkali cleaning, hot water rinsing, application of chemical conversion coating, cold water rinsing, sealing with acid rinse, and thorough drying.

2.2.2.2 Prime Coating

Apply a base coat of epoxy paint, specifically formulated to interact with the top-coat, to the prepared surfaces by roll coating to a dry film thickness of 0.20 plus 0.05 mils. Prime coat must be oven cured prior to application of finish coat.

2.2.2.3 Exterior Finish Coating

Roll coat the finish coating over the primer by roll coating to dry film thickness of 0.80 plus 5 mils (3.80 plus 0.50 mils for Vinyl Plastisol) for a total dry film thickness of 1.00 plus 0.10 mils (4.00 plus 0.10 mils for Vinyl Plastisol). Oven-cure finish coat.

2.2.2.4 Interior Finish Coating

Apply a wash-coat on the reverse side over the primer by roll coating to a dry film thickness of 0.30 plus 0.05 mils for a total dry film thickness of 0.50 plus 0.10 mils. Oven-cured the wash coat.

2.2.2.5 Color

Provide exterior finish color as selected by the Contracting Officer from the manufacturer's standard color chart.

2.2.2.6 Physical Properties

Coating must conform to the industry and manufacturer's standard performance criteria as listed by the following certified test reports:

General:	ASTM D5894 and ASTM D4587
Abrasion:	ASTM D968
Adhesion:	ASTM D3359
Chalking:	ASTM D4214
Chemical Pollution:	ASTM D1308
Color Change and Conformity:	ASTM D2244
Creepage:	ASTM D1654
Cyclic Corrosion Test:	ASTM D5894
Flame Spread:	ASTM E84

Flexibility:	ASTM D522
Formability:	ASTM D522
Gloss at 60 and 85 degrees:	ASTM D523
Humidity:	ASTM D2247 and ASTM D714
Oxidation:	ASTM D610
Pencil Hardness:	ASTM D3363
Reverse Impact:	ASTM D2794
Salt Spray:	ASTM B117
Weatherometer:	ASTM G152, ASTM G153 and ASTM D822

2.3 MISCELLANEOUS METAL FRAMING

Cold-formed metallic-coated steel sheet conforming to ASTM A653/A653M or KS D 3506.

2.3.1 Fasteners for Miscellaneous Metal Framing

Type, material, corrosion resistance, size and sufficient length to penetrate the supporting member a minimum of 2.54 cm (1 inch) with other properties required to fasten miscellaneous metal framing members to supporting members and substrates in accordance with the wall panel manufacturer's and ASCE 7 requirements.

2.4 FASTENERS

2.4.1 General

2.4.1.1 Exposed Fasteners

Provide corrosion resistant fasteners for wall panels, made of coated steel, or nylon capped steel compatible with the sheet panel or flashing and of a type and size recommended by the manufacturer to meet the performance requirements and design loads.

Fasteners for accessories must be the manufacturer's standard. Provide an integral metal washer matching the color of attached material with compressible sealing EPDM gasket approximately 0.24 cm (3/32 inch) thick.

2.4.1.2 Hidden Fasteners

Provide corrosion resistant fasteners recommended by the manufacturer to meet the performance requirements and design loads.

2.4.1.3 Screws

Screws to be corrosion resistant coated steel, aluminum and/or stainless steel being the type and size recommended by the manufacturer to meet the performance requirements.

2.4.1.4 Rivets

Rivets to be closed-end type, corrosion resistant coated steel, aluminum or stainless steel where watertight connections are required.

2.4.1.5 Attachment Clips

Fabricate clips from steel hot-dipped galvanized in accordance with ASTM A653/A653M, Z275 G 90 or Series 300 stainless steel. Size, shape, thickness and capacity as required meeting the insulation thickness and design load criteria specified.

2.5 ACCESSORIES

2.5.1 General

All accessories must be compatible with the metal wall panels. Sheet metal flashing, trim, metal closure strips, caps and similar metal accessories must not be less than the minimum thickness specified for the wall panels. Exposed metal accessories/finishes to match the panels furnished, except as otherwise indicated. Molded foam rib, ridge and other closure strips must be non-absorbent closed-cell or solid-cell synthetic rubber or pre-molded neoprene to match configuration of the panels.

2.5.2 Rubber Closure Strips

Provide closed-cell, expanded cellular rubber conforming to ASTM D1056 and ASTM D1667; extruded or molded to the configuration of the specified wall panel and in lengths supplied by the wall panel manufacturer.

2.5.3 Metal Closure Strips

Provide factory fabricated steel closure strips to be the same gauge, color, finish and profile of the specified wall panel.

2.5.4 Joint Sealants

2.5.4.1 Sealants and Caulking

Provide approved gun type sealants for use in hand- or air-pressure calking guns at temperatures above 4 degrees C (40 degrees F) (or frost-free application at temperatures above minus 12 degrees C (10 degrees F) with minimum solid content of 85 percent of the total volume. Sealants must dry with a tough, durable surface skin which permit remaining soft and pliable underneath, providing a weather-tight joint. No migratory staining is permitted on painted or unpainted metal, stone, glass, vinyl, or wood.

Prime all joints receiving sealants with a compatible one-component or two-component primer as recommended by the wall panel manufacturer.

2.5.4.2 Shop-Applied

Sealant for shop-applied caulking must be non-curing butyl compliant with AAMA 800 to ensure the sealant's plasticity at the time of field erection.

2.5.4.3 Field-Applied

Sealant for field-applied caulking must be an approved gun grade, non-sag one component polysulfide or two-component polyurethane with an initial maximum Shore A durometer hardness of 25, and conforming to ASTM C920, Type II. Color to match panel colors.

2.5.4.4 Pressure Sensitive Tape

Provide pressure sensitive tape sealant, 100 percent solid with a release paper backing; permanently elastic, non-sagging, non-toxic and non-staining as approved by the wall panel manufacturer.

2.6 SHEET METAL FLASHING AND TRIM

2.6.1 Fabrication

Shop fabricate sheet metal flashing and trim where practicable to comply with recommendations in SMACNA 1793 that apply to design, dimensions, metal, and other characteristics of item indicated. Obtain field measurements for accurate fit before shop fabrication.

Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

2.7 REPAIR OF FINISH PROTECTION

Repair paint for color finish enameled wall panel must be compatible paint of the same formula and color as the specified finish furnished by the wall panel manufacturer.

2.8 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal wall panel supports, and other conditions affecting performance of the Work.

Examine primary and secondary wall framing to verify that rafters, purlins, angles, channels, and other structural panel support members and anchorages have been installed within alignment tolerances required by metal wall panel manufacturer, UL, ASTM, ASCE 7 and as required for the geographical area where construction will take place.

Examine solid wall sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal wall panel manufacturer.

Examine roughing-in for components and systems penetrating metal wall panels to verify actual locations of penetrations relative to seam locations of metal wall panels before metal wall panel installation.

Submit to the Contracting Officer a written report, endorsed by Installer, listing conditions detrimental to performance of the Work. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

Clean substrates of substances harmful to insulation, including removing projections capable of interfering with insulation attachment. Miscellaneous framing installation, including sub-purlins, girts, angles, furring, and other miscellaneous wall panel support members and anchorage must be according to metal wall panel manufacturer's written instructions.

3.3 WALL PANEL INSTALLATION

Provide full length metal wall panels, from sill to eave as indicated, unless otherwise indicated or restricted by shipping limitations. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement in accordance with MBMA MBSM.

Erect wall panel system in accordance with the approved erection drawings, the printed instructions and safety precautions of the manufacturer.

Sheets are not to be subjected to overloading, abuse, or undue impact. Bent, chipped, or defective sheets shall not be applied.

Sheets must be erected true and plumb and in exact alignment with the horizontal and vertical edges of the building, securely anchored, and with the indicated eave, and sill.

Work is to allow for thermal movement of the wall panel, movement of the building structure, and to provide permanent freedom from noise due to wind pressure.

Field cutting metal wall panels by torch is not permitted.

3.3.1 Steel Wall Panels

Use stainless-steel fasteners for exterior surfaces and galvanized steel fasteners for interior surfaces.

3.3.2 Aluminum Wall Panels

Use aluminum or stainless-steel fasteners for exterior surfaces and aluminum or galvanized steel fasteners for interior surfaces.

3.3.3 Anchor Clips

Anchor metal wall panels and other components of the Work securely in place, using manufacturer's approved fasteners according to manufacturers' written instructions.

3.3.4 Metal Protection

Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal wall panel manufacturer.

3.3.5 Joint Sealers

Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal wall panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal wall panel manufacturer.

3.4 FASTENER INSTALLATION

Anchor metal wall panels and other components of the Work securely in place, using manufacturer's approved fasteners according to manufacturers' written instructions.

3.5 FLASHING, TRIM AND CLOSURE INSTALLATION

3.5.1 General Requirements

Comply with performance requirements, manufacturer's written installation instructions, and SMACNA 1793. Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams to form permanently watertight and weather resistant.

Install sheet metal work is to form weather-tight construction without waves, warps, buckles, fastening stresses or distortion, and allow for expansion and contraction. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades is to be performed by sheet metal mechanics.

3.5.2 Metal Flashing

Install exposed metal flashing at building corners, sills and eaves, junctions between metal siding and walling. Exposed metal flashing must be the same material, color, and finish as the specified metal wall panel.

Fasten flashing at a minimum of 20.3 cm (8 inches) on center, except where flashing is held in place by the same screws that secure covering sheets.

Flashing is to be furnished in at least 2.44 m (8 foot) lengths. Exposed flashing is to have 2.54 cm (1 inch) locked and blind-soldered end joints, and expansion joints at intervals of not more than 4.88 m (16 feet).

Exposed flashing and flashing subject to rain penetration to be bedded in the specified joint sealant.

Isolate flashing which is in contact with dissimilar metals by means of the specified asphalt mastic material to prevent electrolytic deterioration.

Form drips to the profile indicated, with the edge folded back 1.27 cm (1/2 inch) to form a reinforced drip edge.

3.5.3 Closures

Install metal closure strips at open ends of corrugated or ribbed pattern walls, and at intersection of wall and wall unless open ends are concealed with formed eave flashing; and in other required areas.

Install mastic closure strips at intersection of the wall with metal walling; top and bottom of metal siding; heads of wall openings; and in other required locations.

3.6 WORKMANSHIP

Make lines, arises, and angles sharp and true. Free exposed surfaces from visible wave, warp, buckle, and tool marks. Fold back exposed edges neatly to form a 1.27 cm (1/2 inch) hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections which might affect the application. For installation of items not shown in detail or not covered by specifications conform to the applicable requirements of SMACNA 1793. Provide sheet metal flashing in the angles formed where roof decks abut walls, curbs, ventilators, pipes, or other vertical surfaces and wherever indicated and necessary to make the work watertight.

3.7 ACCEPTANCE PROVISIONS

3.7.1 Erection Tolerances

Erect metal wall panels straight and true with plumb vertical lines correctly lapped and secured in accordance with the manufacturer's written instructions.

3.7.2 Leakage Tests

Finished application of metal wall panels are to be subject to inspection and test for leakage by request of the Contracting Officer, Architect/Engineer. Conduct inspection and tests at no cost to the Government.

Inspection and testing is to be made promptly after erection to permit correction of defects and the removal and replacement of defective materials.

3.7.3 Repairs to Finish

Scratches, abrasions, and minor surface defects of finish may be repaired with the specified repair materials. Finished repaired surfaces must be uniform and free from variations of color and surface texture.

Repaired metal surfaces that are not acceptable to the project requirements and/or Contracting Officer are to be immediately removed and replaced with new material.

3.7.4 Paint-Finish Metal Siding

Paint-finish metal siding will be tested for color stability by the Contracting Officer during the manufacturer's specified guarantee period.

Panels that indicate color changes, fading, or surface degradation, determined by visual examination, must be removed and replaced with new panels at no expense to the Government.

New panels will be subject to the specified tests for an additional year from the date of their installation.

3.8 FIELD QUALITY CONTROL

3.8.1 Construction Monitoring

Make visual inspections as necessary to ensure compliance with specified requirements. Additionally, verify the following:

a. Materials comply with the specified requirements.

b. All materials are properly stored, handled and protected from damage. Damaged materials are removed from the site.

c. Framing and substrates are in acceptable condition, in compliance with specification, prior to application of wall panels.

d. Panels are installed without buckles, ripples, or waves and in uniform alignment and modulus.

e. Side laps are formed, sealed, fastened or seam locked as required.

f. The proper number, type, and spacing of attachment clips and fasteners are installed.

g. Installer adheres to specified and detailed application parameters.

h. Associated flashing and sheet metal are installed in a timely manner in accord with the specified requirements.

3.9 CLEAN-UP AND DISPOSAL

Clean all exposed sheet metal work at completion of installation. Remove metal shavings, filings, nails, bolts, and wires from work area. Remove grease and oil films, excess sealants, handling marks, contamination from steel wool, fittings and drilling debris and scrub the work clean. Exposed metal surfaces must be free of dents, creases, waves, scratch marks, solder or weld marks, and damage to the finish coating.

Collect and place scrap/waste materials in containers. Promptly dispose of demolished materials. Do not allow demolished materials to accumulate on-site; transport demolished materials from government property and legally dispose of them.

-- End of Section --

SECTION 07 51 13

BUILT-UP ASPHALT ROOFING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/SPRI RD-1	(2004) Performance Standard for Retrofit Drains

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM C208	(2008a) Cellulosic Fiber Insulating Board
ASTM C728	(2005; R 2010) Perlite Thermal Insulation Board
ASTM D1863/D1863M	(2005e1; R 2011) Mineral Aggregate Used on Built-Up Roofs
ASTM D1864/D1864M	(1989; R 2009e1) Moisture in Mineral Aggregate Used on Built-Up Roofs
ASTM D1970/D1970M	(2011) Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
ASTM D2170/D2170M	(2010) Kinematic Viscosity of Asphalts (Bitumens)
ASTM D2178	(2004) Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM D312	(2000; R 2006) Standard Specification for Asphalt Used in Roofing
ASTM D3617	(2007) Sampling and Analysis of New Built-Up Roof Membranes
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D4263	(1983; R 2012) Indicating Moisture in Concrete by the Plastic Sheet Method

ASTM D4402	(2006) Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer
ASTM D448	(2008) Sizes of Aggregate for Road and Bridge Construction
ASTM D4586	(2007) Asphalt Roof Cement, Asbestos-Free
ASTM D4601	(2004) Asphalt-Coated Glass Fiber Base Sheet Used in Roofing
ASTM D4637/D4637M	(2012) EPDM Sheet Used in Single-Ply Roof Membrane
ASTM D4869/D4869M	(2005e1; R 2011) Standard Specification for Asphalt-Saturated Organic Felt Underlayment Used in Steep Slope Roofing
ASTM D4897/D4897M	(2001; R 2009) Standard Specification for Asphalt-Coated Glass-Fiber Venting Base Sheet Used in Roofing
ASTM D517	(1998; R 2008) Asphalt Plank
ASTM D6162	(2000a; R 2008) Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using a Combination of Polyester and Glass Fiber Reinforcements
ASTM D6163	(2000; R 2008) Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Glass Fiber Reinforcements
ASTM D6164/D6164M	(2011) Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Polyester Reinforcements
ASTM D6757	(2007) Standard Specification for Underlayment Felt Containing Inorganic Fibers Used in Steep-Slope Roofing
ASTM E108	(2011) Fire Tests of Roof Coverings

FM GLOBAL (FM)

FM 4470	(2010) Single-Ply, Polymer-Modified Bitumen Sheet, Built-up Roof (BUR), and Liquid Applied Roof Assemblies for Use in Class 1 and Noncombustible Roof Deck Construction
FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2532	(2007) Crushed Stone, Crushed Slag and

	Gravel for Single or Multiple Bituminous Surface Treatment
KS F 4052	(2004) Waterproofing Asphalts for Building Construction
KS F 4901	(2012) Asphalt Roofing Felts (Fiber Base, Saturated Bitumen Felts)
KS F 4905	(2009) Perforated Asphalt Roof Felt (Asphalt Glass)
KS M 2270	(2007) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA RoofMan	(2012) The NRCA Roofing Manual

UNDERWRITERS LABORATORIES (UL)

UL 790	(2004; Reprint Oct 2008) Standard Test Methods for Fire Tests of Roof Coverings
UL RMSD	(2011) Roofing Materials and Systems Directory

1.2 DESCRIPTION OF ROOF MEMBRANE SYSTEM

Asphalt applied, four-ply felt, aggregate surfaced or three-ply felt with granule-surfaced modified bitumen cap sheet built-up roof membrane system.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Asphalt
Fiberglass Felt Materials; G
Granule Surface Modified Bitumen Cap Sheet; G
Base Flashing Membrane
Primer
Asphalt Roof Cement
Pre-Manufactured Accessories; G
Roof Walkways
Warranty

SD-06 Test Reports

Samples of Built-Up Roofing

SD-07 Certificates

Qualifications of Applicator

SD-11 Closeout Submittals

Information Card

1.4 QUALITY ASSURANCE

1.4.1 Qualifications of Applicator

The roofing system applicator must be approved, authorized, or licensed in writing by the roofing system manufacturer and must have a minimum of 3 years experience as an approved, authorized, or licensed applicator with the manufacturer and be approved at a level capable of providing the specified warranty. Submit evidence of the roofing system manufacturer's approval.

1.4.2 Fire Resistance

Complete roof covering assembly must:

a. Be Class A rated in accordance with ASTM E108 , FM 4470, or UL 790; and

b. Be listed as part of Fire-Classified roof deck construction in UL RMSD, or Class I roof deck construction in FM APP GUIDE.

1.4.3 Wind Uplift Resistance

The complete roof system assembly shall be rated and installed to resist wind loads calculated in accordance with ASCE 7 and validated by uplift resistance testing in accordance with Factory Mutual (FM) test procedures. Do not install non-rated systems except as approved by the Contracting Officer. Submit licensed engineer's wind uplift calculations and substantiating data to validate any non-rated roof system. Unless otherwise indicated, base wind uplift measurements on a design wind speed of 108 km/h 67 mph in accordance with Building Structure Standard (Notification No. 2009-1245), Ministry of Land, Infrastructure and Transport, Korea.

1.4.4 Preroofing Conference

After approval of submittals and before performing roofing and insulation system installation work, hold a preroofing conference to review the following:

a. Drawings and specifications and submittals related to the roof work;

b. Roof system components installation;

c. Procedure for the roof manufacturer's technical representative's onsite inspection and acceptance of the roofing substrate, the name of the manufacturer's technical representatives, the frequency of the onsite visits, distribution of copies of the inspection reports from the manufacturer's technical representatives to roof manufacturer;

d. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing; and

e. Quality control plan for the roof system installation;

f. Safety requirements.

Coordinate preroofing conference scheduling with the Contracting Officer. The conference must be attended by the Contractor, the Contracting Officer's designated personnel, and personnel directly responsible for the installation of roofing and insulation, flashing and sheet metal work, mechanical and electrical work, other trades interfacing with the roof work, and representative of the roofing materials manufacturer. Before beginning roofing work, provide a copy of meeting notes and action items to all attending parties. Note action items requiring resolution prior to start of roof work.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver materials in manufacturers' original unopened containers and rolls with manufacturer's labels intact and legible. Mark and remove wet or damaged materials from site. Where materials are covered by a referenced specification, container must bear specification number, type, and class, as applicable. Indicate on labels or bill of lading for roofing asphalt the asphalt type, finished blowing temperature (FBT), flash point (FP), and equiviscous temperature (EVT), that is, the temperature at which the viscosity is either 125 centistokes when tested in accordance with ASTM D2170/D2170M or 75 centipoise when tested in accordance with ASTM D4402. Deliver materials in sufficient quantity to allow work to proceed without interruption.

1.5.2 Storage

Protect materials against moisture absorption, contamination, or other damage. Avoid crushing or crinkling of roll materials. Store roll materials on end on clean raised platforms in dry locations in enclosed buildings or trailers with adequate ventilation. Do not store roll materials in buildings under construction until concrete, mortar, and plaster work are finished and dry. Do not store materials outdoors unless approved by the Contracting Officer. Completely cover felts stored outdoors, on and off roof, with waterproof canvas protective covering. Do not use polyethylene sheet as a covering. Tie covering securely to pallets to make completely weatherproof and yet provide sufficient ventilation to prevent condensation. Maintain roll materials at temperature above 10 degrees C (50 degrees F) for a 24-hour period immediately prior to application. Keep aggregate dry as defined by ASTM D1863/D1863M or KS F 2532. Place only those materials to be used during one day's work on the roof at one time. Remove unused materials from the roof at the end of each day's work. Immediately remove wet, contaminated or otherwise damaged or unsuitable materials from the site. Damaged materials may be marked by the Contracting Officer.

1.5.3 Handling

Prevent damage to edges and ends of roll materials. Do not install damaged materials in the work. Select and operate material handling equipment so as not to damage materials or applied roofing.

1.6 ENVIRONMENTAL CONDITIONS

Do not install roofing during precipitation, or fog, or when air temperature is below 4 degrees C (40 degrees F), or when there is ice, frost, moisture or visible dampness on roof deck.

1.7 SEQUENCING

Coordinate the work with other trades to ensure that components which are to be secured to or stripped into the roofing system are available and that permanent flashing and counterflashing are installed as the work progresses. Ensure temporary protection measures are in place to preclude moisture intrusion or damage to installed materials. Application of roofing must immediately follow application of insulation as a continuous operation. Coordinate roofing operations with insulation work so that all roof insulation applied each day is covered with complete felt ply installation the same day.

1.8 WARRANTY

Provide roof system material and workmanship warranties meeting specified requirements. Provide revision or amendment to standard membrane manufacturer warranty to comply with the specified requirements. Minimum manufacturer warranty shall have no dollar limit, cover full system water-tightness, and shall have a minimum duration of 20 years.

Submit all data IAW with requirements of this section. Include in data written acceptance by the roof membrane manufacturer of the products and accessories provided. List products in the applicable wind uplift and fire rating classification listings, unless approved otherwise by the Contracting Officer.

1.8.1 Roof Membrane Manufacturer Warranty

Furnish the roof membrane manufacturer's 20-year no dollar limit roof system materials and installation workmanship warranty, including flashing, insulation, and accessories necessary for a watertight roof system construction. Write the warranty directly to the Government commencing at the time of Government's acceptance of the roof work. Provide the following statement for such warranty:

a. If within the warranty period the roof system, as installed for its intended use in the normal climatic and environmental conditions of the facility, becomes non-watertight, shows evidence of moisture intrusion within the assembly, blisters, splits, tears, delaminates, separates at the seams, or shows evidence of excessive weathering due to defective materials or installation workmanship, the repair or replacement of the defective and damaged materials of the roof system assembly and correction of defective workmanship are the responsibility of the roof membrane manufacturer. All costs associated with the repair or replacement work are the responsibility of the roof membrane manufacturer.

b. The warranty must remain in full force and effect, including emergency temporary repairs performed by others, when the manufacturer or his approved applicator fails to perform the repairs within 72 hours of notification.

1.8.2 Roofing System Installer Warranty

The roof system installer must warrant for a minimum period of two years that the roof system, as installed, is free from defects in installation workmanship, to include the roof membrane, flashing, insulation, accessories, attachments, and sheet metal installation integral to a complete watertight roof system assembly. Write the warranty directly to the Government. The roof system installer is responsible for correction of defective workmanship and replacement of damaged or affected materials. The roof system installer is responsible for all costs associated with the repair or replacement work.

1.8.3 Continuance of Warranty

Approve repair or replacement work that becomes necessary within the warranty period and accomplished in a manner so as to restore the integrity of the roof system assembly and validity of the roof membrane manufacturer warranty for the remainder of the manufacturer warranty period.

1.9 CONFORMANCE AND COMPATIBILITY

The entire roofing and flashing system must be in accordance with specified and indicated requirements, including fire and wind resistance requirements. Work not specifically addressed and any deviation from specified requirements must be in general accordance with recommendations of the NRCA RoofMan, membrane manufacturer published recommendations and details, and compatible with surrounding components and construction. Submit any deviation from specified or indicated requirements to the Contracting Officer for approval prior to installation.

PART 2 PRODUCTS

2.1 GENERAL

Furnish a combination of specified materials that comprise the membrane manufacturer's standard system of the number and type of plies specified. Materials provided must be approved by the roof membrane manufacturer and suitable for the service and climatic conditions of the installation.

2.2 FIBERGLASS FELT MATERIALS

a. Venting Base Sheet: ASTM D4897/D4897M, Type II, without perforations and as approved by the roof membrane manufacturer.

b. Fiberglass Felt Base Sheet: ASTM D4601, Type II, without perforations and as approved by the roof membrane manufacturer.

c. Ply Felt: ASTM D2178, Type IV or VI, or KS F 4905.

2.3 BASE FLASHING MEMBRANE

ASTM D6163. Membrane manufacturer's standard, minimum two-ply modified bitumen membrane flashing system compatible with the built-up roof membrane and as recommended in membrane manufacturer's published literature. Provide a minimum base ply of flashing membrane of 1.8 mm (70 mils) thick. Provide a minimum granule surface modified bitumen flashing cap sheet of 3 mm (120 mils) thick on the selvage edge.

2.4 ASPHALT

ASTM D312, Type II or III, or KS F 4052 in accordance with membrane manufacturer requirements and compatible with the slope conditions of the installation.

2.5 SURFACING MATERIAL

2.5.1 Aggregate for Surfacing Built-up Roofing

Water-worn gravel, crushed stone, or crushed slag, conforming to ASTM D1863/D1863M or KS F 2532, or marble, expanded slag, or expanded shale, conforming to ASTM D1863/D1863M except density not less than 880 kg per cubic meter (55 pcf). Aggregate conforming to gradation sizes No. 6, No. 7, and No. 67 in conformance with ASTM D448 is acceptable provided other requirements of ASTM D1863/D1863M are met. Provide 2 percent maximum moisture content as determined by ASTM D1864/D1864M. Provide light colored and opaque aggregate. Limestone, volcanic rock, crushed shells, and cinders are prohibited.

2.5.2 Granule Surface Modified Bitumen Cap Sheet

ASTM D6163, ASTM D6162, or ASTM D6164/D6164M, as applicable; Type II, Grade G, minimum 3 mm (120 mils) thick at selvage edge, and as required to provide specified fire safety rating.

2.6 PRIMER

ASTM D41/D41M or KS M 2270 for asphalt roofing systems and as approved by the membrane manufacturer.

2.7 ASPHALT ROOF CEMENT

ASTM D4586 for use with asphalt roofing systems, Type II for vertical surfaces and built-up bituminous flashings; Type I for horizontal surfaces and as recommended by the membrane manufacturer.

2.8 CANT STRIPS

Standard cant strips must be of perlite conforming to ASTM C728 or woodfiber conforming to ASTM C208 treated with bituminous impregnation, sizing, or waxing and fabricated to provide maximum 45 degree change in direction of membrane. Provide minimum 38 mm (1-1/2 inch) thick cant strips and provide for minimum 125 mm (5 inch) face and 89 mm (3-1/2 inch) vertical height when installed at 45 degree face angle, except where clearance restricts height to lesser dimension.

2.9 UNSATURATED FELT OR ROSIN-SIZED BUILDING PAPER

Provide rosin-sized sheathing paper weighing minimum 3 kilogram per 10 square meters (5 pounds per 100 square feet) or unsaturated felt weighing approximately 3.7 kilogram per 10 square meters (7-1/2 pounds per 100 square feet).

2.10 FASTENERS AND PLATES

Coated, corrosion resistant fasteners compatible with components being attached and contact surfaces. Conform to FM 4470 for fasteners for attachment to deck substrate of Class I roof deck construction and FM APP GUIDE for the wind resistance specified. Use hard copper fasteners in contact with copper; aluminum or stainless steel fasteners in contact with aluminum; and stainless steel fasteners in contact with stainless steel. For fastening only roofing felts, use fasteners driven through metal discs, or one-piece composite fasteners with heads not less than 25 mm (1 inch) in diameter or 25 mm (1 inch) square with rounded or 45-degree tapered corners.

2.10.1 Wood Substrates and Nailers

Provide 11 gage annular threaded shank nails with 7/16 to 5/8 inch diameter heads; or one-piece composite nails with annular threaded shanks not less than 11 gage for securing felts and metal items. Provide fasteners long enough to penetrate minimum 25 mm (1 inch) into or minimum 6 mm (1/4 inch) through wood substrate materials. Do not penetrate wood decking exposed to view on the underside.

2.10.2 Masonry or Concrete Walls and Vertical Surfaces

Provide hardened steel nails or screws with flat heads, diamond shaped points, and mechanically deformed shanks not less than 25 mm (1 inch) long for securing felts, metal items, and accessories. Use power-driven fasteners only when approved in writing by Contracting Officer.

2.10.3 Metal Plates

Flat corrosion-resistant round stress plates as recommended by the modified bitumen sheet manufacturer's printed instructions and meeting the requirements of FM 4470; minimum 50 mm (2 inches) in diameter. Form discs to prevent dishing or cupping.

2.11 PRE-MANUFACTURED ACCESSORIES

Pre-manufactured accessories must be manufacturer's standard for intended purpose, compatible with the membrane roof system and approved for use by the roof membrane manufacturer.

2.11.1 Pre-fabricated Curbs

Provide gauge as indicated, G90 galvanized or AZ55 galvalume curbs with minimum 100 mm (4 inch) flange for attachment to roof nailers. Provide minimum height of 250 mm (10 inches) above the finished roof membrane surface.

2.12 WALKPADS

Provide polyester reinforced roof walk pads, granule-surfaced modified bitumen membrane material, ASTM D6162 or ASTM D6164/D6164M, minimum 5 mm (200 mils) thick, compatible with the roof membrane and as recommended by the roof membrane manufacturer. Do not exceed 1.2 meters (4 feet) in length for each panel. Other walk pad materials require approval of the Contracting Officer prior to installation.

2.12.1 ROOF WALKWAYS

Provide 950 by 1830 millimeter by 15 millimeter (36 by 72 inches by 1/2 inch) thick asphalt planks, consisting of a homogeneous core of asphalt, plasticizers, and fillers bonded between two saturated and coated facing sheets. Top side must be surfaced with ceramic granules. Conform to ASTM D517, mineral-surfaced asphalt.

2.13 PAVER BLOCKS

Precast concrete, minimum 38 mm (1-1/2 inches) thick, minimum 450 mm (18 inches) square for walkways and minimum 150 mm by 300 mm (6-inch by 12-inch) for use in supporting surface bearing components but extending not less than 50 mm (2 inches) beyond all sides of surface bearing bases. Install walk pad material under all paver blocks.

2.14 ROOF INSULATION BELOW MEMBRANE SYSTEM

Insulation must be compatible with the roof membrane, approved by the membrane manufacturer.

2.15 MEMBRANE LINER

Self-adhering modified bitumen underlayment conforming to ASTM D1970/D1970M or KS F 4901, EPDM membrane liner conforming to ASTM D4637/D4637M, or other waterproof membrane liner material conforming to ASTM D4869/D4869M, or ASTM D6757, and as approved by the Contracting Officer.

2.16 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

Before applying roofing materials, ensure that the following exist:

a. Drains, curbs, cants, control joints, expansion joints, perimeter walls, roof penetrating components, and equipment supports are in place.

b. Surfaces are rigid, clean, dry, smooth, and free of cracks, holes, and sharp changes in elevation. Joints in substrate are sealed to prevent drippage of bitumen into building or down exterior walls. Inspect surfaces and approve immediately before application of roofing and flashings. Apply the roofing and flashings to a smooth and firm surface free from ice, frost, visible moisture, dirt, projections, and foreign materials.

c. The plane of the substrate does not vary more than 6 mm (1/4 inch) within an area 3 by 3 meters (10 by 10 feet) when checked with a 3 meter (10 foot) straight edge placed anywhere on the substrate.

d. Substrate is sloped as indicated to provide drainage.

e. Walls and vertical surfaces are constructed to receive counterflashing and will permit mechanical fastening of the base flashing materials.

f. Treated wood nailers are in place on non-nailable surfaces, to permit nailing of base flashing at minimum height of 8 inches above finished roofing surface.

g. Treated wood nailers are fastened in place at eaves, gable ends, openings, and intersections with vertical surfaces for securing of felts, edging strips, attachment flanges of sheet metal, and roof fixtures. Embedded nailers are flush with deck surfaces. Surface-applied nailers are same thickness as roof insulation.

h. Cants are securely fastened in place in the angles formed by walls and other vertical surfaces. The angle of the cant is approximately 45 degrees and the height of the vertical leg is not less than nominal 89 mm (3-1/2 inches). Lay cants in a solid asphalt mopping or coat of asphalt cement just prior to laying the roofing plies.

i. Venting, if indicated on contract drawings, is provided in accordance with the following:

(1) Edge Venting: Perimeter nailers are kerfed across width of the nailers to permit escape of gaseous pressure at roof edges.

(2) Underside Venting: Vent openings are provided in steel form decking for cast-in-place concrete substrate.

j. Exposed nail heads in wood substrates are properly set. Warped and split boards or sheets have been replaced. There are no cracks or end joints 6 mm (1/4 inch) in width or greater. Knot holes are covered with sheet metal and nailed in place. Wood or plywood decks are covered with rosin paper or unsaturated felt prior to base sheet or roof membrane application. Joints in plywood substrates are taped with 50 mm (2 inch) wide masking tape to prevent air leakage from the underside.k. Insulation boards are installed smoothly and evenly, and are not broken, cracked, or curled. There are no gaps in insulation board joints exceeding 6 mm (1/4 inch) in width. Insulation is being roofed over on the same day the insulation is installed.

l. Cast-in-place concrete substrates have been allowed to cure and the surface dryness requirements specified under paragraph entitled "Field Quality Control" have been met. No viable moisture present when conducting ASTM D4263

m. Prior to application of primer on precast concrete decks, cover joints with a minimum 100 mm (4 inch) strip of felt or bituminous stripping membrane set in bituminous cement.

3.2 PREPARATION

Verify that work of other trades that penetrates the roof deck or requires men and equipment to traverse the roof deck is complete.

Examine deck surfaces for inadequate anchorage, foreign material, moisture, and unevenness which would prevent the execution and quality of application.

Proceed with the roofing application only after defects have been corrected.

Starting work designates acceptance of the surfaces by the Contractor.

3.2.1 Protection of Property

3.2.1.1 Protective Coverings

Install protective coverings at paving and building walls adjacent to hoists and kettles prior to starting the work. Lap protective coverings not less than six inches, secure against wind, and vent to prevent collection of moisture on covered surfaces. Keep protective coverings in place for the duration of the roofing work.

3.2.1.2 Bitumen Stops

Provide felt bitumen stops or other means to prevent bitumen drippage at roof edges, openings, and vertical projections before hot mopped application of the roofing membrane. Form felt bitumen stops with two 300 mm (12 inch) wide strips of organic ply felt. Laminate with and set strips into a coating of asphalt roof cement with one-half of the width overhanging the edge of the roof or opening. Where nailers are provided, nail the strips with roofing nails spaced 300 mm (12 inches) on center in addition to embedding in asphalt roof cement. Protect the free portion of each strip from damage throughout the roofing period. After the plies of felt are in place, fold free portion of the strips back over the roofing membrane and embed in a continuous coating of asphalt roof cement. Secure with roofing nails spaced 75 mm (3 inches) on center.

3.2.2 Equipment

3.2.2.1 Mechanical Application Devices

Provide and maintain mechanical application devices with pneumatic tires that operate without damaging the insulation, roofing membrane, or structural components.

3.2.2.2 Flame-Heated Equipment

Do not place flame-heated equipment on roof. Provide and maintain a fire extinguisher adjacent to flame-heated equipment and on the roof.

3.2.2.3 Open Flame Application Equipment

Use only open flame equipment recommended by the roofing materials manufacturer. Do not ignite open flame equipment when left unattended. Provide and maintain a fire extinguisher adjacent to open flame equipment on the roof.

3.2.3 Priming of Surfaces

Prime all surfaces to be in contact with adhered membrane materials. Apply primer at the rate of 3 liters per 10 square meters (0.75 gallon per 100 square feet) or as recommended by roof membrane manufacturer's printed instructions to promote adhesion of membrane materials. Allow primer to dry prior to application of membrane materials to primed surface. Avoid flammable primer material conditions in torch applied membrane base flashing applications.

3.2.3.1 Priming of Concrete and Masonry Surfaces

After surface dryness requirements have been met, coat concrete and masonry surfaces which are to receive roofing and base flashing uniformly with primer. Allow primer to dry before application of roofing and flashing materials.

3.2.3.2 Priming of Metal Surfaces

Prime flanges of metal components to be embedded into the roofing system prior to setting in bituminous materials or stripping into roofing system.

3.2.4 Covering of Wood Substrate

Cover wood substrate with a layer of unsaturated felt or rosin-sized building paper lapped 50 mm (2 inches) at sides and 100 mm (4 inches) at ends. Nail to hold in place prior to application of roofing system.

3.2.5 Heating of Asphalt

Break up solid asphalt on a surface free of dirt and debris. Heat asphalt in kettle designed to prevent contact of flame with surfaces in contact with the asphalt. Provide visible working thermometer and thermostatic controls set to the temperature limits. Keep controls in working order and calibrated. Use immersion thermometer, accurate within a tolerance of plus or minus one degree C (2 degrees F), to check temperatures of the asphalt frequently. When temperatures exceed maximum specified, remove asphalt from the site. Do not permit cutting back, adulterating, or fluxing of asphalt.

3.2.5.1 Temperature Limitations for Asphalt

Heat and apply asphalt at the temperatures specified below unless specified otherwise by manufacturer's printed application instructions. Use thermometer to check temperature during heating and application. Have kettle attended constantly during heating process to ensure specified temperatures are maintained. Do not heat asphalt above its finished blowing temperature (FBT). Do not heat asphalt between 260 and 274 degrees C (500 and 525 degrees F) for longer than four consecutive hours. Do not heat asphalt to the flash point (FP). Apply asphalt and embed membrane sheets when temperature of asphalt is within plus or minus 14 degrees C (25 degrees F) of the equiviscous temperature (EVT). Before heating and application of asphalt refer to the asphalt manufacturer's label or bill of lading for FP, FBT, and EVT of the asphalt used.

3.3 APPLICATION

Apply roofing materials as specified unless approved otherwise by the Contracting Officer. Keep roofing materials dry before and during application. Except for aggregate surfacing, complete application of roofing in a continuous operation. Begin and apply only as much roofing in one day as can be completed that same day. Maintain specified temperature for asphalt. Do not apply aggregate surfacing until the other roofing application procedures specified herein are completed.

3.3.1 Phased Membrane Construction

Phased application of membrane plies is prohibited. Any delay in modified bitumen cap sheet installation will result in thorough cleaning of the applied membrane material surface and drying immediately prior to cap sheet installation. Priming of the applied membrane surface may be required at the discretion of the Contracting Officer prior to cap sheet installation.

3.3.2 Temporary Roofing and Flashing

Provide watertight temporary roofing and flashing where considerable work by other trades, including, but not limited to, cooling towers, antennas, pipes, and ducts, is to be performed on the roof or where construction scheduling or weather conditions require protection of building interior before permanent roofing system can be installed. Do not install temporary roofing over permanently installed insulation. Provide rigid pads for traffic over temporary roofing.

3.3.2.1 Removal

Completely remove temporary roofing and flashing before continuing with application of permanent roofing system.

3.3.3 Base Sheet Application - General

Fully adhere or spot adhere base sheets in accordance with membrane manufacturer's printed instructions. Provide spot adhesion with hot asphalt applied in 300 mm (12 inch) diameter spots installed in two staggered rows, centered 300 mm (12 inches) in from edge of the base sheet. Roll and broom in the base sheet to ensure full contract with the hot asphalt application. On nailable substrates, mechanically fasten base sheet in conformance with specified wind resistance requirements and membrane manufacturer's printed instructions, and to include increased fastening frequency in corner and perimeter areas. Drive fasteners flush with no dishing or cupping of fastener plate. Where applicable, base sheet may be mechanically fastened in conjunction with insulation to the substrate, in accordance with membrane manufacturers printed instructions. Apply sheets in a continuous operation. Apply sheets with side laps at a minimum of 50 mm (2 inches) unless greater side lap is recommended by the manufacturer's standard written application instructions. Provide end laps of not less than 150 mm (6 inches) and staggered a minimum of 1 meter (36 inches). Apply sheets so that the direction of water flow is over and not against the laps. Extend base sheets approximately 50 mm (2 inches) above the top of cant strips at vertical surfaces and to the top of cant strips elsewhere. Trim base sheet to a neat fit around vent pipes, roof drains, and other projections through the roof. Retrofit roof drains must conform to ANSI/SPRI RD-1. Application must be free of ridges, wrinkles, and buckles.

3.3.3.1 Ventilating Base Sheets

Apply ventilating base sheet material recommended by the roof membrane manufacturer. Extend sheets over roof cants, up vertical surfaces, and terminate under cap flashing; at roof edges terminate sheets under outside edge of perimeter edge nailers or under gravel stop. Top mop perforated ventilating base sheet with a full, continuous mopping of hot asphalt.

3.3.4 Ply Felts

Ensure proper alignment of felts prior to installation. Bucking or backwater laps are prohibited. Apply felts in a continuous operation. Provide starter sheets of felt to maintain the specified number of plies throughout the roofing. Apply felts with side laps in accordance with the material manufacturer's printed instructions for the number of plies to be installed and in uniform alignment. Lap ends not less than 150 mm (6 inches) and stagger one meter (36 inches) minimum. Place the full width of each ply in hot bitumen immediately behind the bitumen applicator. Plies must be laid free of wrinkles, creases, ridges, or fishmouths. Extend felts approximately 50 mm (2 inches) above top of cant strips at vertical surfaces and to top of cant strips elsewhere. Trim felts to a neat fit around vent pipes, roof drains, and other projections. Avoid traffic on mopped surfaces when the bitumen is fluid and for a minimum of one hour after ply application.

3.3.4.1 Hot-Mopping of Ply Felts

Bond plies to each other and to the substrate with hot asphalt. Apply felts immediately following application of asphalt. Do not work ahead with asphalt. At the instant felts come into contact with asphalt, asphalt must be completely fluid, with asphalt temperatures within specified EVT range. Apply asphalt uniformly in a full, continuous mopping and firmly bonding film. Apply asphalt at the rate of approximately 13 kg per 10 square meters (25 pounds per 100 sq. feet) plus or minus 25 percent. Require application rate on the high end of the application range when mopping directly to absorptive insulation substrates of perlite and woodfiber. As felts are rolled into the hot asphalt, immediately squeegee, roll or broom down to eliminate trapped air and to provide tight, smooth laminations without wrinkles, buckles, kinks, or fish mouths. Bitumen must be visible beyond all edges of each ply as it is being installed. Individual ply installation and the completed roof membrane system must be free of air pockets, felt delaminations, ridges, creases, fishmouths, dry laps, or blisters. Do not lay felts dry or turn back laps for mopping between plies.

3.3.4.2 Valleys and Ridges

Valleys: Apply roofing at valleys and waterways in the following manner:

Continue base sheets across valleys and terminate 450 millimeter (18 inches) from the valley.

Continue felt plies across valleys and terminate 300 millimeter (12 inches) from the valley. Terminate exposed laps on a line 300 millimeter (12 inches) from, and parallel to, the gutter valley. Provide two plies of felt, 225 and 300 millimeter (9 and 12 inches) wide, successively mop in over each felt line of the termination.

If the application can be completed without wrinkles, buckles, or fishmouths and if side laps do not face the direction of drainage, roofing felts and base sheets may be laid continuously across or parallel to shallow valleys such as those formed by reverse-slope roofs. For this application, reinforce valleys with one ply of felt, 900 millimeter (36 inches) wide, center on the valley gutter and lay in a solid mopping of asphalt over the top ply of roofing.

3.3.5 Membrane Flashing

Provide two plies of modified bitumen membrane strip flashing and sheet flashing in the angles formed where the roof deck abuts walls, curbs, ventilators, pipes, and other vertical surfaces, and where necessary to make the work watertight. Top ply of flashing must be granule-surfaced modified bitumen membrane. Install flashing after plies of roof membrane felt have been applied but before aggregate surfacing is applied. Cut at a 45 degree angle across terminating end lap area of cap membrane prior to applying adjacent overlapping cap membrane. Press flashing into place to ensure full adhesion and avoid bridging. Ensure full lap seal in all lap areas. Mechanically fasten top edge of base flashing 150 mm (6 inches) on center through minimum 25 mm (1 inch) diameter tin caps with fasteners of sufficient length to embed minimum 25 mm (1 inch) into attachment substrate. Apply matching granules in any areas of asphalt bleed out while the asphalt is still hot. Apply membrane liner over top of exposed nailers and blocking and to overlap top edge of base flashing installation at curbs, parapet walls, expansion joints and as otherwise indicated to serve as waterproof lining under sheet metal flashing components.

3.3.5.1 Strip Flashing

Set primed flanges of sheet metal flashings to be incorporated into roofing system in a uniform coating of asphalt roof cement not less than 1/16 inch thick applied over the ply felts. Strip-in with one layer of smooth surface modified bitumen membrane and cap with granule-surfaced modified bitumen membrane. Set strip flashing in hot asphalt or cement to the tops of the flanges, roofing membrane, and to each other. Use coatings of asphalt roof cement not less than 1/16 inch thick for ply felt. Use hot asphalt or modified bitumen cement for modified bitumen sheets. Extend first stripping ply not less than 100 mm (4 inches) beyond outer edge of flange onto roof membrane. Extend each additional ply 100 mm (4 inches) beyond the edge of the previous ply.

3.3.5.2 Membrane Flashing at Roof Drain

Extend roofing plies to edge of drain bowl opening at roof drain deck flange. Neatly fit and press primed roof drain flashing into heavy coat of asphalt roof cement applied to top of roofing plies. Strip in and completely cover flashing with two layers of modified bitumen sheet, extending the first sheet 150 mm (6 inches) on the roofing beyond the edge of flashing. Extend the cap sheet 150 mm (6 inches) beyond the previous flashing ply. Bond the two layers to the metal flashing and to each other with hot asphalt. Securely clamp membrane, metal flashing, and strip flashing in the flashing clamping ring. Secure clamps so that strip flashing and metal flashing are free from wrinkles and folds. Trim membrane, flashing, and stripping flush with inside of clamping ring.

3.3.5.3 Pre-fabricated Curbs

Anchor prefabricated curbs securely to nailer or other base substrate as indicated and flash with modified bitumen flashing membrane.

3.3.5.4 Set-On Accessories

Where pipe or conduit blocking, supports and similar roof accessories are set on the membrane, adhere walk pad material to bottom of accessories prior to setting on roofing membrane. Specific method of installing set-on accessories must permit normal movement due to expansion, contraction, vibration, and similar occurrences without damaging roofing membrane. Do not mechanically secure set-on accessories through roofing membrane into roof deck substrate.

3.3.5.5 Lightning Protection

Flash or attach lightning protection system components to the roof membrane in a manner acceptable to the roof membrane manufacturer.

3.3.6 Roof Walk pads

Install walk pads at roof access points and where otherwise indicated for traffic areas and for access to mechanical equipment, in accordance with the modified bitumen sheet roofing manufacturer's printed instructions. Provide minimum 150 mm (6 inches) separation between adjacent walk pads to accommodate drainage. Provide walk pad or an additional layer of cap sheet under precast concrete paver blocks to protect the roofing.

3.3.7 Elevated Metal Walkways and Platforms

Provide protection mat of walk pad material, or other material approved by the Contracting Officer, at all surface bearing support locations.

3.3.8 Paver Blocks

Install paver blocks where indicated and as necessary to support surface bearing items traversing the roof area. Set paver block on a layer of walk pad or modified bitumen cap sheet applying over the completed roof membrane.

3.3.9 Aggregate Surfacing

After completion of roof membrane ply and flashing installation, and correction of tears, gouges or other deficiencies in the installed work, apply aggregate surfacing. Uniformly flood coat the surface with hot asphalt at a rate of approximate 2.9 kg (60 pounds) per square. While asphalt is still hot, apply gravel aggregate surfacing material at a rate of 19.5 kg (400 pounds) per square. Provide for full and uniform coverage of the roof surface. Approximately 50 percent of the aggregate must be solidly adhered in the asphalt.

3.3.10 Granule-Surfaced Modified Bitumen Cap Sheet

Inspect underlying applied membrane and repair free of damage, holes, puncture, gouges, abrasions, and any other defects, and free of moisture, loose materials, debris, sediments, dust, and any other conditions required by the membrane manufacturer prior to cap sheet installation. Provide cleaning and artificial drying with heated blowers or torches to ensure clean, dry surface prior to cap sheet application. When delays in cap sheet installation may have occurred, do not apply cap sheet if underlying materials have been exposed to rain or frozen precipitation within the previous 24 hours. Unroll cap sheet membrane and allow to rest a minimum of 1 hour prior to installation and as otherwise recommended by the membrane manufacturer. Apply cap sheet in same direction as the underlying felt plies. Align cap membrane and apply with minimum 75 mm (3 inch) side laps and minimum 150 mm (6 inch) end laps and as otherwise required by membrane manufacturer. Set cap sheet in hot asphalt. Cap sheet may be torch applied with approval of the Contracting Officer and written approval of the felt membrane manufacturer, and as recommended by the modified bitumen membrane manufacturer. Cut at a 45 degree angle across selvage edge of cap membrane to be overlapped in end lap areas prior to applying overlapping cap membrane. Minimize traffic on newly installed cap sheet membrane.

3.3.10.1 Backnailing of Cap Sheet Membrane

Unless otherwise recommended by the roof membrane manufacturer and approved by the Contracting Officer, install the modified bitumen cap sheet to provide for end laps at nailer locations. Nail the modified bitumen cap sheet at the end lap area across the width of the sheet. Nail within 25 mm (1 inch) of each edge of the sheet and at 200 mm to 215 mm (8 to 8-1/2 inches) on center across the width of the sheet in a staggered fashion. Provide nails with a 25 mm (1 inch) diameter metal cap or nail through 25 mm (1 inch) diameter caps. Cover nails by overlapping adjacent upslope sheet at the end lap area.

3.3.11 Correction of Deficiencies

Where any form of deficiency is found, take additional measures to determine the extent of the deficiency and corrective actions must be as directed by the Contracting Officer. Where interply moppings are too light, apply additional two plies of felt in full moppings of asphalt. Apply with 100 mm (4 inch) side and end laps. Where free water, skips, excessive voids, dry laps, desponding or any form of delamination are discovered between the plies, remove and rebuild affected area. Correction of inadequate number of plies, improper lap widths, or non-uniform or excessive asphalt mopping must be as directed by the Contracting Officer. Where insulation is found to be wet, remove insulation and provide new built-up roofing and insulation.

3.3.12 Clean Up

Remove debris, scraps, containers and other rubbish and trash resulting from installation of the roofing system from job site each day.

3.4 PROTECTION OF APPLIED ROOFING

3.4.1 Protection Against Moisture Absorption

When precipitation is imminent and at the end of each day's work, protect applied roofing as follows:

3.4.2 Water Cutoffs

Straighten insulation line using loose-laid cut insulation sheets and seal the terminated edge of modified bitumen roofing system in an effective manner. Remove the water cutoffs to expose the insulation when resuming work, and remove the insulation sheets used for fill-in.

3.4.3 Temporary Flashing for Permanent Roofing

Provide temporary flashing at drains, curbs, walls and other penetrations and terminations of roofing sheets until permanent flashings can be applied. Remove temporary flashing before applying permanent flashing.

3.4.4 Temporary Walkways, Runways, and Platforms

Do not permit storing, walking, wheeling, and trucking directly on applied roofing materials. Provide temporary walkways, runways, and platforms of smooth clean boards, mats or planks as necessary to avoid damage to applied roofing materials, and to distribute weight to conform to live load limits of roof construction. Use rubber-tired equipment for roofing work.

3.4.5 Glaze Coat

Use light glaze coating of bitumen to waterproof roof areas requiring extended time to complete. Glaze coating must be at the discretion of the Contracting Officer. Apply bitumen glaze coat on exposed felts at a rate of0.25 kg to 0.50 kg per square meter (5 to 10 pounds per square foot). Lower application rates, in accordance with membrane manufacturer's recommendations, may be required when modified bitumen cap sheet surfacing is specified. Provide valleys and low areas that may pond water with glaze coating.

3.5 FIELD QUALITY CONTROL

Perform field tests in the presence of the Contracting Officer. Notify the Contracting Officer one day before performing tests.

3.5.1 Test for Surface Dryness

Before application of insulation or membrane materials and starting work on the area to be roofed, perform test for surface dryness in accordance with the following:

a. Foaming: When poured on the surface to which materials are to be applied, one pint of asphalt when heated in the range of 176 to 204 degrees C (350 to 400 degrees F), must not foam upon contact.

b. Strippability: After asphalt used in the foaming test application has cooled to ambient temperatures, test coating for adherence. Should a portion of the sample be readily stripped clean from the surface, do not consider the surface to be dry and do not start application. Should rain occur during application, stop work and do not resume until surface has been tested by the method above and found dry.

c. Prior to installing any roof system on a concrete deck, conduct a test per ASTM D4263. The deck is acceptable for roof system application when there is no visible moisture on underside of plastic sheet after 24 hours.

3.5.2 Construction Monitoring

During progress of the roof work, Contractor is responsible for making visual inspections to ensure compliance with specified parameters. Additionally, verify the following:

a. Equipment is in working order. Metering devices are accurate.

b. Materials are not installed in adverse weather conditions.

c. Substrates are in acceptable condition, in compliance with specification, prior to application of subsequent materials.

Nailers and blocking are provided where and as needed.

Insulation substrate is smooth, properly secured to its substrate, and without excessive gaps prior to membrane application.

The proper number, type, and spacing of fasteners are installed.

Materials comply with the specified requirements.

All materials are properly stored, handled and protected from moisture or other damages.

Asphalt is heated and applied within the specified temperature parameters.

Hot asphalt application is provided uniformly for voidless coverage and as necessary to ensure full adhesion of materials. Materials are set in place while asphalt is within the specified temperature range.

The proper number and types of plies are installed, with the specified overlaps.

Applied membrane surface is inspected, cleaned, dry, and repaired as necessary prior to cap sheet installation.

Membrane is without ridges, wrinkles, kinks, fishmouths, or other voids or delaminations.

Installer adheres to specified and detailed application parameters.

Associated flashings and sheet metal are installed in a timely manner in accord with the specified requirements.

Temporary protection measures are in place at the end of each work shift.

3.5.3 Samples of Built-Up Roofing

After application of specified roofing felts and prior to applying surfacing, take field samples of built-up roofing as directed by the Contracting Officer. Take and test samples in accordance with ASTM D3617 and at locations selected by the Contracting Officer immediately prior to cutting. Cut 100 mm by 1000 mm (4 inch by 40 inch) samples across felt laps in a manner to expose the specified number of plies. The 100 mm (4 inch)edge must coincide with an edge lap of felt and not be positioned over an end lap. Use 100 mm by 1000 mm (4 inch by 40 inch) samples for visual inspection. The Contracting Officer will inspect the samples for the specified number of plies, bond between plies, skips in interply moppings, uniform asphalt mopping, presence of excessive voids or large voids in the ply construction, presence of harmful foreign materials, visible presence of moisture in the sandwich and wet insulation. Use 300 mm by 300 mm (12 inch by 12 inch) cut samples to calculate bitumen quantities in accordance with ASTM D3617 and directed by the Contracting Officer. Do not proceed with surfacing until all deficiencies disclosed as a result of cut tests have been corrected and approved by the Contracting Officer. Where cuts are not retained by the Contracting Officer or disposed, set cut strip back in cut area and patch as specified.

Submit test results on roofing field samples, verifying composition of sample. Submit one hard copy and one digital copy (.pdf - text searchable) of laboratory analysis within 30 calendar days after samples are taken. Submit reports in accordance with ASTM D3617.

3.5.3.1 Number of Cut Tests

Take cut samples as directed by the Contracting Officer for quality assurance validation or as necessary to determine the extent of deficiencies discovered in the construction. Except where cut samples are taken to investigate deficiencies, provide no more than two cut samples per 1000 square meters (10800 square feet) or one cut sample from each day's work, whichever is greater.

3.5.3.2 Sample Cutting Device

Provide a rectangular, 100 mm by 1000 mm (4 inch by 40 inch) template and 300 mm by 300 mm (12 inch by 12 inch) template, of a type that will permit accurate cutting of samples with standard roofing knives. Keep cutting edge of knife clean by washing in solvent after each cut.

3.5.3.3 Patching Cut-Out Area

Immediately after inspection, replace cut-out sample. When sample is needed for laboratory analysis or other circumstance makes it unavailable, substitute a new section of equivalent size and structure. For non-nailable decks, replace sample in hot asphalt. For nailable decks, insert one ply of ply felt into opening from which sample was taken and sprinkle nail to hold in place; coat felt heavily with asphalt roof cement and press cutout sample firmly into asphalt roof cement. Repair area of cut with new patch of the same number of plies as the primary roof membrane. Extend the first ply minimum 150 mm (6 inches) all around the cut area. Extend each additional ply minimum 100 mm (4 inches) beyond the previous ply.

3.5.4 Roof Drain Test

After roofing system is complete except for surfacing, perform the following test of roof drains and adjacent roofing for water tightness. Plug roof drains and fill with water to edge of drain sump for 8 hours. Do not plug secondary overflow drains at same time as adjacent primary drain. To ensure some drainage from roof, do not test all drains at same time. Measure water at beginning and end of the test period. When precipitation occurs during test period, repeat test. When water level falls, remove water, thoroughly dry, and inspect the installation. Repair or replace roofing at drain to provide for a properly installed watertight flashing seal. Repeat test until there is no water leakage.

3.6 INFORMATION CARD

For each roof, furnish one paper copy & one digital copy (.pdf - text searchable) of an information card for facility records and a photoengraved 1 mm (0.032 inch) thick aluminum card for exterior display. Paper and aluminum copies of card must be 215 mm by 275 mm (8-1/2 by 11 inches) minimum. Information cards must identify facility name and number; location; contract number; approximate roof area; detailed roof system description, including deck type, membrane, number of plies, method of application, manufacturer, insulation and cover board system and thickness; presence of tapered insulation for primary drainage, presence of vapor retarder; date of completion; installing contractor identification and contact information; membrane manufacturer warranty expiration, warranty reference number, and contact information. Install aluminum card at roof top or access location as directed by the Contracting Officer and provide paper and digital copies to the Contracting Officer.

-- End of Section --

SECTION 07 53 23

ETHYLENE-PROPYLENE-DIENE-MONOMER ROOFING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/SPRI RD-1	(2004) Performance Standard for Retrofit Drains

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM D448	(2008) Sizes of Aggregate for Road and Bridge Construction
ASTM D4637/D4637M	(2012) EPDM Sheet Used in Single-Ply Roof Membrane
ASTM D4811	(2006) Nonvulcanized (Uncured) Rubber Sheet Used as Roof Flashing
ASTM D6369	(1999; R 2006) Design of Standard Flashing Details for EPDM Roof Membranes
ASTM E108	(2011) Fire Tests of Roof Coverings

FM GLOBAL (FM)

FM 4470	(2010) Single-Ply, Polymer-Modified Bitumen Sheet, Built-up Roof (BUR), and Liquid Applied Roof Assemblies for Use in Class 1 and Noncombustible Roof Deck Construction
FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA RoofMan	(2012) The NRCA Roofing Manual

UNDERWRITERS LABORATORIES (UL)

UL 790	(2004; Reprint Oct 2008) Standard Test

	Methods for Fire Tests of Roof Coverings
UL RMSD	(2011) Roofing Materials and Systems Directory

1.2 DESCRIPTION OF ROOF MEMBRANE SYSTEM

Fully adhered, mechanically fastened, or combination fully adhered and mechanically fastened EPDM roof membrane system applied over insulation, recovery board, concrete roof deck substrate.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roof Plan Drawing
Wind Load Calculations

SD-03 Product Data

Ballast Pavers
EPDM Sheet
Flashings
Flashing Accessories
Fasteners and PlatesBallast
Roof Insulation
Protection Mat
Pre-Manufactured Accessories
Warranty

SD-05 Design Data

Wind Uplift Calculations; G

SD-06 Test Reports

Roof Drain Test

SD-07 Certificates

Qualification of Manufacturer
Qualification of Applicator
Wind Uplift Resistance; G
Fire Resistance; G

SD-08 Manufacturer's Instructions

Application
Application Method
Instructions For Membrane Flashing

SD-11 Closeout Submittals

Information Card
Instructions To Government Personnel

1.3.1 Shop Drawings

Roof plan drawing depicting wind load calculations and boundaries of enhanced perimeter and corner attachments of roof system components, location of perimeter half-sheets, spacing of perimeter, corner, and infield fasteners, as applicable. The drawing must reflect the project roof plan of each roof level and conditions indicated. Provide all slopes and drain locations.

1.4 QUALITY ASSURANCE

1.4.1 Qualification of Manufacturer

EPDM sheet roofing membrane manufacturer must have at least 5 years experience in manufacturing EPDM roofing products. Provide certification that the manufacturer of the roof membrane meets this requirement.

1.4.2 Qualification of Applicator

Provide certification that the roofing system applicator has been approved, authorized, or licensed in writing by the roof membrane manufacturer and has a minimum of three years experience as an approved, authorized, or licensed applicator with that manufacturer and is approved at a level capable of providing the specified warranty. The applicator must supply the names, locations and client contact information of 5 projects of similar size and scope that the applicator has constructed using the manufacturer's roofing products submitted for this project within the previous three years.

1.4.3 Fire Resistance

Complete roof covering assembly must:

a. Be Class A rated in accordance with ASTM E108, FM 4470, or UL 790; and

b. Be listed as part of Fire-Classified roof deck construction in the UL RMSD or Class I roof deck construction in the FM APP GUIDE.

FM or UL approved components of the roof covering assembly must bear the appropriate FM or UL label. Submit the roof system assembly fire rating classification listing.

1.4.4 Wind Uplift Resistance

The complete roof system assembly shall be rated and installed to resist wind loads calculated in accordance with ASCE 7 and validated by uplift resistance testing in accordance with Factory Mutual (FM) test procedures. Submit the roof system assembly wind uplift classification listing. Do not install non-rated systems except as approved by the Contracting Officer. Submit licensed engineer's wind uplift calculations and substantiating data validating the wind resistance of any non-rated roof system. Base wind uplift measurements based on a design wind speed in accordance with ASCE 7 and/or other applicable building code requirements.

1.4.5 Preroofing Conference

After approval of submittals and before performing roofing and insulation system installation work, hold a preroofing conference to review the following:

a. Drawings, specifications and submittals related to the roof work;

b. Roof system components installation;

c. Procedure for the roof manufacturer's technical representative's onsite inspection and acceptance of the roofing substrate, the name of the manufacturer's technical representatives, the frequency of the onsite visits, distribution of copies of the inspection reports from the manufacturer's technical representative;

d. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing; and

e. Quality control plan for the roof system installation;

f. Safety requirements.

Coordinate preroofing conference scheduling with the Contracting Officer. The conference must be attended by the Contractor, the Contracting Officer's designated personnel, personnel directly responsible for the installation of roofing and insulation, flashing and sheet metal work, mechanical and electrical work, other trades interfacing with the roof work, and representative of the roofing materials manufacturer. Before beginning roofing work, provide a copy of meeting notes and action items to all attending parties. Note action items requiring resolution prior to start of roof work.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver materials in their original, unopened containers or wrappings with labels intact and legible. Where materials are covered by a referenced specification number, the labels must bear the specification number, type, class, and shelf life expiration date where applicable. Deliver materials in sufficient quantity to allow continuity of work.

1.5.2 Storage

Store and protect materials from damage and weather in accordance with manufacturer's printed instructions, except as specified otherwise. Keep materials clean and dry. Store and maintain adhesives, sealants, primers and other liquid materials above 15 degrees C (60 degrees F). Insulated hot boxes or other enclosed warming devices must be required in cold weather. Mark and remove damaged materials from the site. Use pallets to support and canvas tarpaulins to completely cover material materials stored outdoors. Do not use polyethylene as a covering. Locate materials temporarily stored on the roof in approved areas, and distribute the load to stay within the live load limits of the roof construction. Remove unused materials from the roof at the end of each day's work.

1.5.3 Handling

Prevent damage to edges and ends of roll materials. Do not install damaged materials in the work. Select and operate material handling equipment so as not to damage materials or applied roofing. Do not use materials contaminated by exposure or moisture. Remove contaminated materials from the site. When hazardous materials are involved, adhere to the special precautions of the manufacturer. Adhesives may contain petroleum distillates and may be extremely flammable; prevent personnel from breathing vapors, and do not use near sparks or open flame.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not install EPDM sheet roofing during high winds or inclement weather, or when there is ice, frost, moisture, or visible dampness on the substrate surface, or when condensation develops on surfaces during application. Unless recommended otherwise by the EPDM sheet manufacturer and approved by the Contracting Officer, do not install EPDM sheet when air temperature is below 4 degrees C (40 degrees F) or within 3 degrees C (5 degrees F) of the dew point. Follow manufacturer's printed instructions for installation during cold weather conditions.

1.7 SEQUENCING

Coordinate the work with other trades to ensure that components which are to be secured to or stripped into the roofing system are available and that permanent flashing and counterflashing are installed as the work progresses. Ensure temporary protection measures are in place to preclude moisture intrusion or damage to installed materials. Application of roofing must immediately follow application of insulation as a continuous operation. Coordinate roofing operations with insulation work so that all roof insulation applied each day is covered with roof membrane installation the same day.

1.8 WARRANTY

Provide roof system material and workmanship warranties meeting specified requirements. Provide revision or amendment to standard membrane manufacturer warranty as required to comply with the specified requirements. Minimum manufacturer warranty shall have no dollar limit, cover full system water-tightness, and shall have a minimum duration of 20 years.

Include a written acceptance by the roof membrane manufacturer of the insulation and other products and accessories to be provided. List products in the applicable wind uplift and fire rating classification listings, unless approved otherwise by the Contracting Officer.

1.8.1 Roof Membrane Manufacturer Warranty

Furnish the roof membrane manufacturer's 20 year no dollar limit roof system materials and installation workmanship warranty, including flashing, insulation, and accessories necessary for a watertight roof system construction. The warranty must run directly to the Government and commence at time of Government's acceptance of the roof work. The warranty must state that:

a. If within the warranty period the roof system, as installed for its intended use in the normal climatic and environmental conditions of the facility, becomes non-watertight, shows evidence of moisture intrusion within the assembly, splits, tears, cracks, delaminates, separates at the seams, shrinks to the point of bridging or tenting membrane at transitions, or shows evidence of excessive weathering due to defective materials or installation workmanship, the repair or replacement of the defective and damaged materials of the roof system assembly and correction of defective workmanship must be the responsibility of the roof membrane manufacturer. The roof membrane manufacturer is responsible for all costs associated with the repair or replacement work.

b. When the manufacturer or his approved applicator fail to perform the repairs within 72 hours of notification, emergency temporary repairs performed by others does not void the warranty.

1.8.2 Roofing System Installer Warranty

The roof system installer must warrant for a period of two years that the roof system, as installed, is free from defects in installation workmanship, to include the roof membrane, flashing, insulation, accessories, attachments, and sheet metal installation integral to a complete watertight roof system assembly. Write the warranty directly to the Government. The roof system installer is responsible for correction of defective workmanship and replacement of damaged or affected materials. The roof system installer is responsible for all costs associated with the repair or replacement work.

1.8.3 Continuance of Warranty

Approve repair or replacement work that becomes necessary within the warranty period and accomplish in a manner so as to restore the integrity of the roof system assembly and validity of the roof membrane manufacturer warranty for the remainder of the manufacturer warranty period.

1.9 CONFORMANCE AND COMPATIBILITY

The entire roofing and flashing system must be in accordance with specified and indicated requirements, including fire and wind resistance requirements. Work not specifically addressed and any deviation from specified requirements must be in general accordance with recommendations of the NRCA RoofMan, membrane manufacturer published recommendations and details, ASTM D6369, and compatible with surrounding components and construction. Submit any deviation from specified or indicated requirements to the Contracting Officer for approval prior to installation.

PART 2 PRODUCTS

2.1 MATERIALS

Coordinate with other specification sections related to the roof work. Furnish a combination of specified materials that comprise a roof system acceptable to the roof membrane manufacturer and meeting specified requirements. Protect materials provided from defects and make suitable for the service and climatic conditions of the installation.

2.1.1 EPDM Sheet

Ethylene Propylene Diene Terpolymer (EPDM), ASTM D4637/D4637M, Type II, scrim or fabric reinforced, 1.2 mm (0.045 inch) nominal thickness for mechanically fastened, fully adhered, or combined fully adhered and mechanically fastened application. The minimum thickness must not be less than minus 10 percent of the specified thickness value. EPDM membrane thickness specified is exclusive of backing material on the EPDM membrane. Principal polymer used in manufacture of the membrane sheet must be greater than 95 percent EPDM. Width and length of sheet must be maximum width attainable as recommended by the manufacturer to minimize field formed seams in the field of the roof.

2.1.2 Seam Tape

Double-sided synthetic rubber tape, minimum 0.76 mm (0.03 inch) thick, minimum75 mm (3 inches) wide. The roof membrane manufacturer must supply seam tape recommended by the manufacturer's printed data for forming watertight bond of EPDM sheet materials to each other for the application specified and conditions encountered. 150 mm (6 inch) wide tape is required for seam seals along lines of mechanical attachment of membrane.

2.1.3 Lap Splice Adhesive

Low volatile organic compound (VOC) synthetic rubber adhesive as supplied by roof membrane manufacturer and recommended by the manufacturer's printed data for forming watertight bond of EPDM sheet membrane materials to each other in areas of membrane flashing. Do not use splice adhesive to form membrane seams in field of roof or at standard base flashing conditions.

2.1.4 Bonding Adhesive

Low volatile organic compound (VOC) or synthetic rubber adhesive as supplied by roof membrane manufacturer and recommended by the manufacturer's printed data for bonding EPDM membrane materials to insulation, wood, metal, concrete or other substrate materials. Do not use bonding adhesive to bond membrane materials to each other.

2.1.5 Lap Cleaner, Lap Sealant, and Edge Treatment

As supplied by the roof membrane manufacturer and recommended by the manufacturer's printed data.

2.1.6 Water Cutoff Mastic/Water Block

As supplied by the roof membrane manufacturer and recommended by the manufacturer's printed data.

2.1.7 Membrane Flashings and Flashing Accessories

Membrane flashing, including self-adhering membrane flashing, perimeter flashing, flashing around roof penetrations, and prefabricated pipe seals, must be minimum 1.1 mm (0.045 inch) minimum cured EPDM, as recommended by the roof membrane manufacturer or minimum 1.4 mm (0.055 inch) thick uncured EPDM sheet in compliance with ASTM D4811, Type I. Use cured EPDM membrane to the maximum extent recommended by the roof membrane manufacturer. Limit uncured flashing material to reinforcing inside and outside corners and angle changes in plane of membrane, and to flash scuppers, pourable sealer pockets, and other formed penetrations or unusually shaped conditions as recommended by the roof membrane manufacturer where the use of cured material is impractical.

2.1.7.1 Flashing Tape

EPDM-backed synthetic rubber tape, minimum 150 mm (6 inch) wide as supplied by the roof membrane manufacturer and recommended by the manufacturer's printed data.

2.1.8 Membrane Fasteners and Plates

Coated, corrosion-resistant fasteners as recommended by the roof membrane manufacturer and meeting the requirements of FM 4470 and FM APP GUIDE for Class I roof deck construction and the wind uplift resistance specified. As supplied and warranted for the substrate type(s) by EPDM sheet manufacturer and recommended by EPDM sheet manufacturer's printed data.

2.1.8.1 Stress Plates for Fasteners

Flat corrosion-resistant round stress plates as recommended by the roof membrane manufacturer's printed instructions and meeting the requirements of FM 4470; not less than 50 mm (2 inches) in diameter. Provide pre-formed discs to prevent dishing or cupping.

2.1.8.2 Auxiliary Fasteners

Corrosion resistance screws, nails, or anchors suitable for intended attachment purpose and as recommended by the roof membrane manufacturer.

2.1.8.3 Powder-Driven Fasteners

Powder-driven fasteners may be used only when approved in writing.

2.1.8.4 Metal Disks

Provide flat metal disks of minimum 25 mm (1 inch) in diameter. Metal disks must be of nonferrous material compatible with the nails or fasteners.

2.1.9 Ballast

2.1.9.1 Stone Ballast

Smooth, rounded, river-washed stone graded in accordance with ASTM D448, sizes 1, 2, 24, 3, and 4, nominal 19 mm to 38 mm (3/4 inch to 1-1/2 inches) diameter, except as recommended otherwise by the roof membrane manufacturer and approved by the Contracting Officer.

2.1.9.2 Ballast Pavers

Provide weather resistant, precast interlocking concrete roof pavers , and as recommended by the roof membrane manufacturer. Provide pavers of minimum 20,680 kPa (3000 psi) 51,700 kPa (7500 psi) compressive strength, weigh not less than 58 kg per square meter (12 pounds per square foot), not less than 50 mm (2 inches) thick and nominal 600 mm (24 inches) in length and width and without sharp edges and projections. If indicated, elevate pavers above the roof membrane surface with paver manufacturer's recommended pedestal system to provide for level walking surface as required by the roof membrane manufacturer.

2.1.10 Protection Mat / Slip Sheet

Minimum 154 gram per square meter (4.5 ounce per square yard) 200 gram per square meter (6 ounce per square yard) ultraviolet resistant polypropylene, non-woven, needle punched fabric for use as protection mat under ballast system and as recommended by the roof membrane manufacturer.

2.1.11 Pre-Manufactured Accessories

Pre-manufactured accessories must be manufacturer's standard for intended purpose, compatible with the membrane roof system and approved for use by the roof membrane manufacturer.

2.1.11.1 Pre-fabricated Curbs

Provide gauge as indicated, G90 galvanized or AZ55 galvalume curbs with minimum 100 mm (4 inch) flange for attachment to roof nailers. Provide minimum height of 250 mm (10 inches) above the finished roof membrane surface.

2.1.12 Rubber Walkboards and Precast Concrete Paver Block Walkways

If indicated, provide either of the following:

2.1.12.1 Rubber Walkboards

Preformed reprocessed rubber, compatible with the EPDM sheet, 6 mm (1/4 inch) minimum thickness, and weighing not less than .68 kg per square meter (1-1/2 pounds per square foot).

2.1.12.2 Precast Concrete Paver Block

Precast concrete blocks, 450 mm by 450 mm (18 inches by 18 inches), without sharp edges and projections, and weighing no more than 20 kg (45 pounds) 36 kg (80 pounds) each.

2.1.13 Roof Insulation Below EPDM Sheet

Insulation system and facer material must be compatible with membrane application specified and as approved by the roof membrane manufacturer.

2.1.14 Wood Products

Do not allow fire retardant treated materials be in contact with EPDM membrane or EPDM accessory products, unless approved by the membrane manufacturer and the Contracting Officer.

2.1.15 Membrane Liner

EPDM membrane liner conforming to ASTM D4637/D4637M, or other waterproof membrane liner material as approved by the roof membrane manufacturer and the Contracting Officer.

2.2 FLASHING CEMENT

Provide a self-vulcanizing butyl compound flashing cement for splicing laps and for flashings workable at minus 7 degrees C (20 degrees F). Obtain a recommendation for such flashing cement from the roofing membrane manufacturer.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Ensure that the following conditions exist prior to application of the roofing materials:

a. Drains, curbs, control joints, expansion joints, perimeter walls, roof penetrating components, and equipment supports are in place.

b. Surfaces are rigid, clean, dry, smooth, and free from cracks, holes, and sharp changes in elevation.

c. The plane of the substrate does not vary more than 6 mm (1/4 inch) within an area 3 by 3 meters (10 by 10 feet) when checked with a 3 meter (10 foot) straight edge placed anywhere on the substrate.

d. Substrate is sloped to provide positive drainage.

e. Walls and vertical surfaces are constructed to receive counterflashing, and will permit mechanical fastening of the base flashing materials.

f. Treated wood nailers are in place on non-nailable surfaces, to permit nailing of base flashing at minimum height of 200 mm (8 inches) above finished roofing surface.

g. Pressure-preservative treated wood nailers are fastened in place at eaves, gable ends, openings, and intersections with vertical surfaces for securing of membrane, edging strips, attachment flanges of sheet metal, and roof fixtures.

h. Avoid contact of EPDM materials with fire retardant treated wood, except as approved by the roof membrane manufacturer and Contracting Officer.

i. Cants are securely fastened in place in the angles formed by walls and other vertical surfaces. The angle of the cant is 45 degrees and the height of the vertical leg is not less than 89 mm (3-1/2 inches).

j. Venting, if indicated, shall be provided in accordance with the following:

   (1) Edge Venting: Perimeter nailers are kerfed across the width of the nailers to permit escape of gaseous pressure at roof edges.

   (2) Underside Venting: Vent openings are provided in steel form decking for cast-in-place concrete substrate.

   (3) Vapor pressure relief vents: Holes equal to the outside diameter

of vents are provided through the insulation where vents are required. Space vents in accordance with membrane manufacturer's recommendations.

k. Exposed nail heads in wood substrates are properly set. Warped and split boards or sheets have been replaced. There are no cracks or end joints 6 mm (1/4 inch) in width or greater. Joints in plywood substrates are taped or otherwise sealed to prevent air leakage from the underside.

l. Insulation boards are installed smoothly and evenly, and are not broken, cracked, or curled. There are no gaps in insulation board joints exceeding 6 mm (1/4 inch) in width. Insulation is being roofed over on the same day the insulation is installed.

3.2 APPLICATION

Apply entire EPDM sheet utilizing fully adhered, mechanically fastened, or combined fully adhered and mechanically fastened application methods. Apply roofing materials as specified herein unless approved otherwise by the Contracting Officer.

3.2.1 Special Precautions

a. Do not dilute coatings or sealants unless specifically recommended by the materials manufacturer's printed application instructions. Do not thin liquid materials with cleaners used for cleaning EPDM sheet.

b. Keep liquids in airtight containers, and keep containers closed except when removing materials.

c. Use liquid components, including adhesives, within their shelf life period. Store adhesives at 15 to 27 degrees C (60 to 80 degrees F) prior to use. Avoid excessive adhesive application and adhesive spills, as they can be destructive to some elastomeric sheets and insulations; follow adhesive manufacturer's printed application instructions. Mix and use liquid components in accordance with label directions and manufacturer's printed instructions.

d. Provide clean, dry cloths or pads for applying membrane cleaners and cleaning of membrane

e. Do not use heat guns or open flame to expedite drying of adhesives or primers.

f. Require workmen and others who walk on the membrane to wear clean, soft-soled shoes to avoid damage to roofing materials.

g. Do not use equipment with sharp edges which could puncture the EPDM sheet.

h. Shut down air intakes and any related mechanical systems and seal open vents and air intakes when applying solvent-based materials in the area of the opening or intake. Coordinate shutdowns with the Contracting Officer.

3.2.2 EPDM Sheet Roofing

Provide a watertight roof membrane sheet free of contaminants and defects that might affect serviceability. Provide a uniform, straight, and flat edge. Unroll EPDM sheet roofing in position without stretching membrane. Inspect for holes. Remove sections of EPDM sheet roofing that are damaged. Allow sheets to relax minimum 30 minutes before seaming. Lap sheets as specified, to shed water, and as recommended by the roof membrane manufacturer's published installation instructions for the application required but not less than 75 mm (3 inches) in any case.

3.2.3 Application Method

Submit manufacturer's instruction for application, including pattern and frequency of mechanical attachments required in the field of roof, corners, and perimeters to provide for the specified wind resistance

3.2.3.1 Combined Fully Adhered and Mechanically Fastened Application

Install combined fully adhered and mechanically fastened roof membrane system in the manner specified and including seaming, perimeter and infield fastening and half sheets.

3.2.3.2 Fully Adhered Membrane Application

Layout membrane and side lap adjoining sheets in accordance with membrane manufacturer's printed installation instructions. Allow for sufficient membrane to form proper membrane terminations. Remove dusting agents and dirt from membrane and substrate areas where bonding adhesives are to be applied. Apply specified adhesive evenly and continuously to substrate at rates recommended by the roof membrane manufacturer's printed application instructions. When adhesive is spray applied, roll with a paint roller to ensure proper contact and coverage. Do not apply bonding adhesive to surfaces of membrane in seam or lap areas. Allow adhesive to flash off or dry to consistency prescribed by manufacturer before adhering sheets to the substrate. Roll each sheet into adhesive slowly and evenly to avoid wrinkles; broom or roll the membrane to remove air pockets and fishmouths and to ensure full, continuous bonding of sheet to substrate. Form field lap splices or seams as specified. Check all seams and ensure full lap seal. Apply lap sealant to all adhesive formed seams and all cut edges of reinforced membrane materials.

3.2.3.3 Mechanically Fastened Membrane Application

Layout membrane and lap adjoining sheets in accordance with membrane manufacturer's printed instructions such that a minimum 75 mm (3 inch) seam width is maintained and seam width is as required by tested assembly meeting specified wind resistance requirements. Account for additional overlap required for placement of fasteners and plates or battens beyond the closed seam. Allow for sufficient membrane to form proper membrane terminations. Ensure membrane is free of wrinkles and ridges in the installation. Mechanically secure the membrane sheet with specified fasteners in the lap area. Space fasteners as required to provide the wind uplift resistance specified and in accordance with submitted fastener patterns for the field, corner, and perimeter roof areas. Set fasteners firm to plate or batten. Form field lap splices or seams as specified. Check all seams and ensure full lap seal. Apply lap sealant to all adhesive formed seams and all cut edges of reinforced membrane materials.

3.2.3.4 Ballasted Membrane Application

Layout membrane and side lap adjoining sheets a minimum of 100 mm (4 inches) and according to membrane manufacturer's printed instructions. Allow for sufficient membrane to form proper membrane terminations. Ensure membrane is free of wrinkles and ridges in the installation. Form field lap splices or seams as specified and of width required by the membrane manufacturer's installation instructions. Check seams to ensure continuous seal before proceeding with further work. Apply continuous lap sealant to all adhesive formed seams and all cut edges of reinforced membrane materials.

3.2.4 Tape Seams / Lap Splices

Field form seams, or lap splices, with seam tape in accordance with membrane manufacturer's printed instructions and as specified. Clean and prime mating surfaces in the seam area. After primer has dried or set in accordance with membrane manufacturer's instructions, apply seam tape to bottom membrane and roll with a 75 mm to 100 mm (3 to 4 inch) wide smooth silicone or steel hand roller, or other manufacturer approved rolling device, to ensure full contact and adhesion of tape to bottom membrane. Tape end laps must be minimum 25 mm (1 inch). Roll top membrane into position to check for proper overlap and alignment. Remove release paper from top of seam tape and form seam splice. Ensure top membrane contact with seam tape as release paper is removed. Roll the closed seam with a smooth silicone or steel hand roller, rolling first across the width of the seam then along the entire length, being careful not to damage the membrane. Apply minimum 225 mm (9 inch) long strip of membrane-backed flashing tape over T-intersections of roof membrane. Roll tape to ensure full adhesion and seal over T-joint.

3.2.5 Adhesive Seams / Lap Splices

Use only field-applied adhesive formed seams where approved by the membrane manufacturer and the Contracting Officer. Do not use adhesive formed seams for field of roof membrane seaming. Thoroughly and completely clean mating surfaces of materials throughout the lap area. Remove all dirt, dust, and contaminants and allow to dry.

Apply primer as recommended by the membrane manufacturer. Apply splice adhesive with a 75 mm to 100 mm (3 to 4 inch) wide, 13 mm (1/2 inch) thick, solvent-resistant brush in a smooth, even coat with long brush strokes. Bleed out brush marks. Do not apply adhesive in a circular motion. Simultaneously apply adhesive to both mating surfaces in an approximate 0.63 mm to 0.75 mm (0.025 to 0.030 inch) wet film thickness, or other thickness as recommended by the roof membrane manufacturer's printed instructions.

Allow the splice adhesive to set-up in accordance with membrane manufacturer's printed instructions. Perform manufacturer recommended field check to test for adhesive readiness prior to closing seam. Apply a 3 mm to 6 mm (1/8 inch to 1/4 inch) bead of in-seam sealant approximately 13 mm (1/2 inch) from the inside edge of the lower membrane sheet prior to closing the seam. Ensure the in-seam sealant does not extend onto the splice adhesive. Maintain the full adhered seam width required. Roll the top membrane onto the mating surface. Roll the seam area with a 50 mm to 75 mm (2 to 3 inch) wide, smooth silicone or steel hand roller. A minimum of 2 hours after joining sheets and when the lap edge is dry, clean the lap edge with membrane manufacturer's recommended cleaner and apply a 6mm to 9 mm (1/4 inch to 3/8 inch) bead of lap sealant centered on the seam edge. With a feathering tool, immediately feather the lap sealant to completely cover the splice edge, leaving a mound of sealant over the seam edge. Apply lap sealant to all adhesive formed seams.

3.2.6 Perimeter Attachment

Adhesive bond or mechanically secure roof membrane sheet at roof perimeter in a manner to comply with wind resistance requirements and in accordance with membrane manufacturer's printed application instructions. When adhesively bonding a mechanically fastened system in perimeter areas, the perimeter boundary of the adhesive bond must be the same as the boundary required for additional perimeter mechanical fastening to meet wind resistance requirements.

3.2.7 Securement at Base Tie-In Conditions

Mechanically fasten the roof membrane at penetrations, at base of curbs and walls, and at all locations where the membrane turns and angle greater than 4 degrees (1:12). Space fasteners a maximum of 300 mm (12 inches) on center, except where more frequent attachment is required to meet specified wind resistance or where recommended by the roof membrane manufacturer. Flash over fasteners with a fully adhered layer of material as recommended by the roof membrane manufacturer's printed data.

3.3 FLASHINGS

3.3.1 General

Provide flashings in the angles formed at walls and other vertical surfaces and where required to make the work watertight, except where metal flashings are indicated.

Provide a one-ply flashing membrane, as specified for the system used, and install immediately after the roofing membrane is placed and prior to finish coating where a finish coating is required. Flashings must be stepped where vertical surfaces abut sloped roof surfaces. Provide sheet metal reglet in which sheet metal cap flashings are installed not more than 400 mm (16 inches) and not less than 200 mm (8 inches) above the roofing surfaces. Exposed joints and end laps of flashing membrane must be made and sealed in the manner required for roofing membrane.

3.3.2 Membrane Flashing

Submit Manufacturer's instructions for membrane flashing. Include detailed application instructions and standard manufacturer drawings altered as required by these specifications. Explicitly identify in writing, differences between manufacturer's printed instructions and the specified requirements.

Install flashing and flashing accessories as the roof membrane is installed. Apply flashing to cleaned surfaces and as recommended by the roof membrane manufacturer and as specified. Utilize cured EPDM membrane flashing and prefabricated accessory flashings to the maximum extent recommended by the roof membrane manufacturer. Limit uncured flashing material to reinforcing inside and outside corners and angle changes in plane of membrane, and to flashing scuppers, pourable sealer pockets, and other formed penetrations or unusually shaped conditions as recommended by the roof membrane manufacturer where the use of cured material is impractical. Extend base flashing not less than 200 mm (8 inches) above roofing surface and as necessary to provide for seaming overlap on roof membrane as recommended by the roof membrane manufacturer.

Seal flashing membrane for a minimum of 75 mm (3 inches) on each side of fastening device used to anchor roof membrane to nailers. Completely adhere flashing sheets in place. Seam flashing membrane in the same manner as roof membrane, except as otherwise recommended by the membrane manufacturer's printed instructions and approved by the Contracting Officer. Reinforce all corners and angle transitions by applying uncured membrane to the area in accordance with roof membrane manufacturer recommendations. Mechanically fasten top edge of base flashing with manufacturer recommended termination bar fastened at maximum 300 mm (12 inches) on center. Install sheet metal flashing over the termination bar in the completed work. Mechanically fasten top edge of base flashing for all other terminations in a manner recommended by the roof membrane manufacturer. Apply membrane liner over top of exposed nailers and blocking and to overlap top edge of base flashing installation at curbs, parapet walls, expansion joints and as otherwise indicated to serve as waterproof lining under sheet metal flashing components.

3.3.3 Flashing at Roof Drain

Provide a tapered insulation sump into the drain bowl area. Do not exceed tapered slope of (4:12) (18 degrees) for unreinforced membrane and (1:12) (5 degrees) for reinforced membrane. Provide tapered insulation with surface suitable for adhering membrane in the drain sump area. Avoid field seams running through or within 600 mm (24 inches) of roof drain, or as otherwise recommended by the roof membrane manufacturer. Adhere the membrane to the tapered in the drain sump area. Apply water block mastic and extend membrane sheets over edge of drain bowl opening at the roof drain deck flange in accordance with membrane manufacturer's printed application instructions. Insure membrane free of wrinkles and folds in the drain area. Securely clamp membrane in the flashing clamping ring. Ensure membrane is cut to within 20 mm (3/4 inch) of inside rim of clamping ring to maintain drainage capacity. Do not cut back to bolt holes. Retrofit roof drains must conform to ANSI/SPRI RD-1.

3.3.4 PRE-FABRICATED CURBS

Securely anchor prefabricated curbs to nailer or other base substrate and flashed with EPDM membrane flashing materials.

3.3.5 Set-On Accessories

Where pipe or conduit blocking, supports and similar roof accessories, or isolated paver block, are set on the membrane, adhere reinforced membrane or walk pad material, as recommended by the roof membrane manufacturer, to bottom of accessories prior to setting on roofing membrane. Specific method of installing set-on accessories must permit normal movement due to expansion, contraction, vibration, and similar occurrences without damaging roofing membrane. Do not mechanically secure set-on accessories through roofing membrane into roof deck substrate.

3.3.6 Lightning Protection

Flash lightning protection system components or attach to the roof membrane in a manner acceptable to the roof membrane manufacturer.

3.4 ROOF WALKPADS

Install walk pads at roof access points and where otherwise indicated for traffic areas and for access to mechanical equipment, in accordance with the roof membrane manufacturer's printed instructions. Provide minimum 150 mm (6 inches) separation between adjacent walk pads to accommodate drainage.

3.4.1 Elevated Metal Walkways and Platforms

Provide for protection of roof membrane by placing reinforced membrane or walk pad material, or other material approved by the Contracting Officer, at all surface bearing support locations.

3.5 CORRECTION OF DEFICIENCIES

Where any form of deficiency is found, additional measures must be taken as deemed necessary by the Contracting Officer to determine the extent of the deficiency and corrective actions must be as directed by the Contracting Officer.

3.6 CLEAN UP

Remove debris, scraps, containers and other rubbish and trash resulting from installation of the roofing system from job site each day.

3.7 PROTECTION OF APPLIED ROOFING

At the end of the day's work and when precipitation is imminent, protect applied membrane roofing system from water intrusion.

3.7.1 Water Cutoffs

Straighten insulation line using loose-laid cut insulation sheets and seal the terminated edge of the roof membrane system in an effective manner. Remove the water cut-offs to expose the insulation when resuming work, and remove the insulation sheets used for fill-in.

3.7.2 Temporary Flashing for Permanent Roofing

Provide temporary flashing at drains, curbs, walls and other penetrations and terminations of roofing sheets until permanent flashings can be applied. Remove temporary flashing before applying permanent flashing.

3.7.3 Temporary Walkways, Runways, and Platforms

Do not permit storing, walking, wheeling, and trucking directly on applied roofing materials. Provide temporary walkways, runways, and platforms of smooth clean boards, mats or planks as necessary to avoid damage to applied roofing materials, and to distribute weight to conform to live load limits of roof construction. Use rubber-tired equipment for roofing work.

3.8 FIELD QUALITY CONTROL

3.8.1 Construction Monitoring

During progress of the roof work, Contractor must make visual inspections as necessary to ensure compliance with specified parameters. Additionally, verify the following:

a. Equipment is in working order. Metering devices are accurate.

b. Materials are not installed in adverse weather conditions.

c. Substrates are in acceptable condition, in compliance with specification, prior to application of subsequent materials.

Nailers and blocking are provided where and as needed.

Insulation substrate is smooth, properly secured to its substrate, and without excessive gaps prior to membrane application.

The proper number, type, and spacing of fasteners are installed.

Materials comply with the specified requirements.

All materials are properly stored, handled and protected from moisture or other damages. Liquid components are properly mixed prior to application.

Membrane is allowed to relax prior to seaming. Adhesives are applied uniformly to both mating surfaces and checked for proper set prior to bonding mating materials. Mechanical attachments are spaced as required, including additional fastening of membrane in corner and perimeter areas as required.

Membrane is properly overlapped.

Membrane seaming is as specified and seams are hand rolled to ensure full adhesion and bond width. All seams are checked at the end of each work day.

Applied membrane is inspected and repaired as necessary prior to ballast installation.

Membrane is fully adhered without ridges, wrinkles, kinks, fishmouths.

Installer adheres to specified and detailed application parameters.

Associated flashings and sheet metal are installed in a timely manner in accord with the specified requirements.

Ballast is within the specified weight range.

Temporary protection measures are in place at the end of each work shift.

3.8.2 Roof Drain Test

After completing roofing but prior to Government acceptance, perform the following test for water tightness. Plug roof drains and fill with water to edge of drain sump for 8 hours. Retrofit roof drains must conform to ANSI/SPRI RD-1. Do not plug secondary overflow drains at the same time as adjacent primary drain. To ensure some drainage from roof, do not test all drains at same time. Measure water at beginning and end of the test period. When precipitation occurs during test period, repeat test. When water level falls, remove water, thoroughly dry, and inspect installation; repair or replace roofing at drain to provide for a properly installed watertight flashing seal. Repeat test until there is no water leakage.

3.9 INSTRUCTIONS TO GOVERNMENT PERSONNEL

Furnish written and verbal instructions on proper maintenance procedures to designated Government personnel. Prepare and submit written instructions in accordance with Section 01 33 00 SUBMITTAL PROCEDURES. Furnish instructions by a competent representative of the roof membrane manufacturer and include a minimum of 4 hours on maintenance and emergency repair of the membrane. Include a demonstration of membrane repair, and give sources of required special tools. Furnish information on safety requirements during maintenance and emergency repair operations. Include copies of Material Safety Data Sheets for maintenance/repair materials.

3.10 INFORMATION CARD

For each roof, furnish one paper copy & one digital copy (.pdf - text searchable) of an information card for facility records and a photoengraved 1 mm (0.032) inch thick aluminum card for exterior display. Paper and aluminum copies of card must be 215 mm by 275 mm (8-1/2 by 11 inches) minimum. Information card must identify facility name and number; location; contract number; approximate roof area; detailed roof system description, including deck type, membrane, number of plies, method of application, manufacturer, insulation and cover board system and thickness; presence of tapered insulation for primary drainage, presence of vapor retarder; date of completion; installing contractor identification and contact information; membrane manufacturer warranty expiration, warranty reference number, and contact information. Install aluminum card at roof top or access location as directed by the Contracting Officer and provide paper and digital copies to the Contracting Officer.

-- End of Section --

SECTION 07 60 00

FLASHING AND SHEET METAL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/SPRI RD-1	(2004) Performance Standard for Retrofit Drains

AMERICAN WELDING SOCIETY (AWS)

AWS D1.2/D1.2M	(2008) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A308/A308M	(2010) Standard Specification for Steel Sheet, Terne (Lead-Tin Alloy) Coated by the Hot Dip Process
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B370	(2012) Standard Specification for Copper Sheet and Strip for Building Construction

ASTM B69	(2011) Standard Specification for Rolled Zinc
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D41/D41M	(2011) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D4586	(2007) Asphalt Roof Cement, Asbestos-Free

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 3705	(2008) Hot rolled stainless steel plates, sheets and strip
KS D 5201	(2009) Copper and Copper Alloy Sheets, Plates and Strips
KS D 6701	(2012) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6704	(2001) Soft Solder
KS D 6759	(2011) Aluminum and Aluminum Alloy Extruded Shapes
KS F 4901	(2012) Asphalt Roofing Felts (Fiber Base, Saturated Bitumen Felts)
KS M 2270	(2007) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

1.2 GENERAL REQUIREMENTS

Finished sheet metalwork will form a weathertight construction without waves, warps, buckles, fastening stresses or distortion, which allows for expansion and contraction. Sheet metal mechanic is responsible for cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades. Coordinate installation of sheet metal items used in conjunction with roofing with roofing work to permit continuous roofing operations.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings

SD-03 Product Data

Flashing

SD-11 Closeout Submittals

Quality Control Plan

1.4 DELIVERY, HANDLING, AND STORAGE

Package and protect materials during shipment. Uncrate and inspect materials for damage, dampness, and wet-storage stains upon delivery to the job site. Remove from the site and replace damaged materials that cannot be restored to like-new condition. Handle sheet metal items to avoid damage to surfaces, edges, and ends. Store materials in dry, weather-tight, ventilated areas until immediately before installation.

1.5 Drawings

Prepare and submit shop drawings. Include items listed below as applicable. Indicate thicknesses, dimensions, fastenings and anchoring methods, provisions necessary for thermal expansion and contraction, and other requirements within this section. Scaled manufacturer's catalog data may be submitted for factory fabricated items.

a. Covering on flat, sloped, or curved surfaces

b. Gutters

c. Downspouts

d. Expansion joints

e. Gravel stops and fascias

f. Splash pans

g. Flashing for roof drains

h. Base flashing

i. Counterflashing

j. Flashing at roof penetrations

k. Reglets

l. Scuppers

m. Copings

n. Drip edge

o. Conductor heads

p. Open valley flashing

q. Eave flashing

PART 2 PRODUCTS

2.1 MATERIALS

Do not use lead, lead-coated metal, or galvanized steel. Use any metal listed by SMACNA Arch. Manual for a particular item, unless otherwise specified or indicated. Conform to the requirements specified and to the thicknesses and configurations established in SMACNA Arch. Manual for the materials. Different items need not be of the same metal, except that if copper is selected for any exposed item, all exposed items must be copper.

Furnish sheet metal items in 2400 to 3000 mm (8 to 10 foot) lengths. Single pieces less than 2400 mm (8 feet) long may be used to connect to factory-fabricated inside and outside corners, and at ends of runs. Factory fabricate corner pieces with minimum 300 mm (12 inch) legs. Provide accessories and other items essential to complete the sheet metal installation. Provide accessories made of the same or compatible materials as the items to which they are applied. Fabricate sheet metal items of the materials specified below and to the gage, thickness, or weight shown in Table I at the end of this section, unless otherwise indicated. Provide sheet metal items with mill finish unless specified otherwise. Where more than one material is listed for a particular item in Table I, each is acceptable and may be used except as follows:

2.1.1 Exposed Sheet Metal Items

Must be of the same material. Consider the following as exposed sheet metal: gutters, including hangers; downspouts; gravel stops and fascias; cap, valley, steeped, base, and eave flashings and related accessories.

2.1.2 Drainage

Do not use copper for an exposed item if drainage from that item will pass over exposed masonry, stonework or other metal surfaces.

2.1.3 Copper, Sheet and Strip

ASTM B370, cold-rolled temper, H 00 (standard), or KS D 5201.

2.1.4 Steel Sheet, Zinc-Coated (Galvanized)

ASTM A653/A653M or KS D 3506.

2.1.4.1 Finish

Exposed exterior items of zinc-coated steel sheet must have a baked-on, factory-applied color coating of polyvinylidene fluoride or other equivalent fluorocarbon coating applied after metal substrates have been cleaned and pretreated. Provide finish coating dry-film thickness of 0.020 to 0.033 mm (0.8 to 1.3 mils) and color as indicated.

2.1.5 Zinc Sheet and Strip

ASTM B69, Type I, a minimum of 0.61 mm (0.024 inch) thick.

2.1.6 Stainless Steel

ASTM A167 or KS D 3705, Type 302 or 304, 2D Finish, fully annealed, dead-soft temper.

2.1.7 Terne-Coated Steel

Minimum of 350 by 500 mm (14 by 20 inches) with minimum of 18 kilogram (40 pound) coating per double base box. ASTM A308/A308M.

2.1.8 Aluminum Alloy Sheet and Plate

ASTM B209M (ASTM B209), or KS D 6701 form alloy and temper appropriate for use.

2.1.8.1 Finish

Exposed exterior sheet metal items of aluminum must have a baked-on, factory-applied color coating of polyvinylidene fluoride (PVF2) or other equivalent fluorocarbon coating applied after metal substrates have been cleaned and pretreated. Provide finish coating dry-film thickness of 0.020 to 0.033 mm (0.8 to 1.3 mils) and color as indicated.

2.1.9 Aluminum Alloy, Extruded Bars, Rods, Shapes, and Tubes

ASTM B221M (ASTM B221), or KS D 6759.

2.1.10 Solder

ASTM B32, 95-5 tin-antimony, or KS D 6704.

2.1.11 Polyvinyl Chloride Reglet

ASTM D1784, Type II, Grade 1, Class 14333-D, 1.9 mm (0.075 inch) minimum thickness.

2.1.12 Bituminous Plastic Cement

ASTM D4586, Type I.

2.1.13 Roofing Felt

ASTM D226/D226M Type I or Type II, or KS F 4901.

2.1.14 Asphalt Primer

ASTM D41/D41M or KS M 2270.

2.1.15 Fasteners

Use the same metal or a metal compatible with the item fastened. Use stainless steel fasteners to fasten dissimilar materials.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Metal Roofing

3.1.1.1 Standing-seam Method

Make standing seams parallel with slope of roof. Fabricate sheets into long lengths at shop by locking short dimensions together and thoroughly soldering joints thus formed. In applying metal, turn up one edge of course at each side seam at right angles 40 mm (1.5 inches). Then install 50 by 75 mm (2 by 3 inch) cleats spaced 300 mm (12 inches) apart by fastening one end of each cleat to roof with two 25 mm (one inch) long nails and folding roof end back over nail heads. Turn end adjoining turned-up side seam up over upstanding edge of course. Turn up adjoining edge of next course 45 mm (1.75 inches) and abutting upstanding edges locked, turned over, and flattened against one side of standing seam. Make standing seams straight, rounded neatly at the top edges, and stand about 25 mm (one inch) above roof deck. All sheets must be same length, except as required to complete run or maintain pattern. Locate transverse joints of each panel half way between joints in adjacent sheets. Align joints of alternate sheets horizontally to produce uniform pattern, as shown in SMACNA Arch. Manual.

3.1.1.2 Flat-seam Method

Lay metal so short dimension is parallel to gutter or eave lines and so water will flow over and not into seams. Make seams by turning edges of sheet 20 mm (3/4 inch) and lock and solder together. If sheets are laid one at a time, secure to roof deck with cleats, using three cleats to each sheet, two on long side and one on short side. Use cleats 50 mm (2 inches) wide, hooked over 20 mm (3/4 inch) upturned edges of sheets, and nail to roof deck with two 25 mm (one inch) long nails. Turn back roof end of cleat over nail heads before next sheet is applied. If desired, sheets may be made into long lengths at shop by locking short dimensions together and soldering seams thus formed. Turn long lengths 20 mm (3/4 inch), and secure each length to roof deck by cleats spaced 300 mm (12 inches) apart. Mallet and solder seams after pans are in place." All sheets to be same length, except as required to complete run or maintain pattern. Locate transverse joints of each panel half way between joints in adjacent sheets. Align joints of alternate sheets horizontally to produce uniform pattern, as shown in SMACNA Arch. Manual.

3.1.2 Workmanship

Make lines and angles sharp and true. Free exposed surfaces from visible wave, warp, buckle, and tool marks. Fold back exposed edges neatly to form a 13 mm (1/2 inch) hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections. For installation of items not shown in detail or not covered by specifications conform to the applicable requirements of SMACNA 1793, Architectural Sheet Metal Manual. Provide sheet metal flashing in the angles formed where roof decks abut walls, curbs, ventilators, pipes, or other vertical surfaces and wherever indicated and necessary to make the work watertight. Join sheet metal items together as shown in Table II, unless otherwise indicated.

3.1.3 Nailing

Confine nailing of sheet metal generally to sheet metal having a maximum width of 450 mm (18 inches). Confine nailing of flashing to one edge only. Space nails evenly not over 75 mm (3 inches) on center and approximately 13 mm (1/2 inch) from edge unless otherwise specified or indicated. Face nailing will not be permitted. Where sheet metal is applied to other than wood surfaces, include in shop drawings, the locations for sleepers and nailing strips required to secure the work.

3.1.4 Cleats

Provide cleats for sheet metal 450 mm (18 inches) and over in width. Space cleats evenly not over 300 mm (12 inches) on center unless otherwise specified or indicated. Unless otherwise specified, provide cleats of 50 mm wide by 75 mm long (2 inches) wide by 3 inches) long and of the same material and thickness as the sheet metal being installed. Secure one end of the cleat with two nails and the cleat folded back over the nailheads. Lock the other end into the seam. Where the fastening is to be made to concrete or masonry, use screws and drive in expansion shields set in concrete or masonry. Pretin cleats for soldered seams.

3.1.5 Bolts, Rivets, and Screws

Install bolts, rivets, and screws where indicated or required. Provide compatible washers where required to protect surface of sheet metal and to provide a watertight connection. Provide mechanically formed joints in aluminum sheets 1.0 mm (0.040 inch) or less in thickness.

3.1.6 Seams

Straight and uniform in width and height with no solder showing on the face.

3.1.6.1 Flat-lock Seams

Finish not less than 20 mm (3/4 inch) wide.

3.1.6.2 Lap Seams

Finish soldered seams not less than 25 mm (one inch) wide. Overlap seams not soldered, not less than 75 mm (3 inches).

3.1.6.3 Loose-Lock Expansion Seams

Not less than 75 mm (3 inches) wide; provide minimum 25 mm (one inch) movement within the joint. Completely fill the joints with the specified sealant, applied at not less than 3 mm (1/8 inch) thick bed.

3.1.6.4 Standing Seams

Not less than 25 mm (one inch) high, double locked without solder.

3.1.6.5 Flat Seams

Make seams in the direction of the flow.

3.1.7 Soldering

Where soldering is specified, apply to copper, terne-coated stainless steel, zinc-coated steel, and stainless steel items. Pretin edges of sheet metal before soldering is begun. Seal the joints in aluminum sheets of one mm (0.040 inch) or less in thickness with specified sealants. Do not solder aluminum.

3.1.7.1 Edges

Scrape or wire-brush the edges of lead-coated material to be soldered to produce a bright surface. Flux brush the seams in before soldering. Treat with soldering acid flux the edges of stainless steel to be pretinned. Seal the joints in aluminum sheets of one mm (0.040 inch) or less in thickness with specified sealants. Do not solder aluminum.

3.1.8 Welding and Mechanical Fastening

Use welding for aluminum of thickness greater than one mm (0.040 inch). Aluminum one mm (0.040 inch) or less in thickness must be butted and the space backed with formed flashing plate; or lock joined, mechanically fastened, and filled with sealant as recommended by the aluminum manufacturer.

3.1.8.1 Welding of Aluminum

Use welding of the inert gas, shield-arc type. For procedures, appearance and quality of welds, and the methods used in correcting welding work, conform to AWS D1.2/D1.2M.

3.1.8.2 Mechanical Fastening of Aluminum

Use No. 12, aluminum alloy, sheet metal screws or other suitable aluminum alloy or stainless steel fasteners. Drive fasteners in holes made with a No. 26 drill in securing side laps, end laps, and flashings. Space fasteners 300 mm (12 inches) maximum on center. Where end lap fasteners are required to improve closure, locate the end lap fasteners not more than 50 mm (2 inches) from the end of the overlapping sheet.

3.1.9 Protection from Contact with Dissimilar Materials

3.1.9.1 Copper or Copper-bearing Alloys

Paint with heavy-bodied bituminous paint surfaces in contact with dissimilar metal, or separate the surfaces by means of moistureproof building felts.

3.1.9.2 Aluminum

Do not allow aluminum surfaces in direct contact with other metals except stainless steel, zinc, or zinc coating. Where aluminum contacts another metal, paint the dissimilar metal with a primer followed by two coats of aluminum paint. Where drainage from a dissimilar metal passes over aluminum, paint the dissimilar metal with a non-lead pigmented paint.

3.1.9.3 Metal Surfaces

Paint surfaces in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

3.1.9.4 Wood or Other Absorptive Materials

Paint surfaces that may become repeatedly wet and in contact with metal with two coats of aluminum paint or a coat of heavy-bodied bituminous paint.

3.1.10 Expansion and Contraction

Provide expansion and contraction joints at not more than 9750 mm (32 foot) intervals for aluminum and at not more than 12 meter (40 foot) intervals for other metals. Provide an additional joint where the distance between the last expansion joint and the end of the continuous run is more than half the required interval. Space joints evenly. Join extruded aluminum gravel stops and fascias by expansion and contraction joints spaced not more than 3600 mm (12 feet) apart.

3.1.11 Base Flashing

Lay the base flashings with each course of the roof covering, shingle fashion, where practicable, where sloped roofs abut chimneys, curbs, walls, or other vertical surfaces. Extend up vertical surfaces of the flashing not more than 200 mm (8 inches) and not less than 100 mm (4 inches) under the roof covering. Where finish wall coverings form a counterflashing, extend the vertical leg of the flashing up behind the applied wall covering not less than 150 mm (6 inches). Overlap the flashing strips or shingles with the previously laid flashing not less than 75 mm (3 inches). Fasten the strips or shingles at their upper edge to the deck. Horizontal flashing at vertical surfaces must extend vertically above the roof surface and fastened at their upper edge to the deck a minimum of 150 mm (6 inches) on center with large headed aluminum roofing nails hex headed, galvanized shielded screws a minimum of 2-inch lap of any surface. Solder end laps and provide for expansion and contraction. Extend the metal flashing over crickets at the up-slope side of curbs and similar vertical surfaces extending through sloping roofs, the metal flashings. Extend the metal flashings onto the roof covering not less than 115 mm (4.5 inches) at the lower side of dormer walls and similar vertical surfaces extending through the roof decks. Install and fit the flashings so as to be completely weathertight. Provide factory-fabricated base flashing for interior and exterior corners. Do not use metal base flashing on built-up roofing.

3.1.12 Counterflashing

Except where indicated or specified otherwise, insert counterflashing in reglets located from 230 to 250 mm (9 to 10 inches) above roof decks, extend down vertical surfaces over upturned vertical leg of base flashings not less than 75 mm (3 inches). Fold the exposed edges of counterflashings 13 mm (1/2 inch). Where stepped counterflashings are required, they may be installed in short lengths a minimum 200 mm (8 inches) by 200 mm 8 inches) or may be of the preformed one-piece type. Provide end laps in counterflashings not less than 75 mm (3 inches) and make it weathertight with plastic cement. Do not make lengths of metal counterflashings exceed 3000 mm (10 feet). Form the flashings to the required shapes before installation. Factory-form the corners not less than 300 mm (12 inches) from the angle. Secure the flashings in the reglets with lead wedges and space not more than 450 mm (18 inches) apart; on short runs, place wedges closer together. Fill caulked-type reglets or raked joints which receive counterflashing with caulking compound. Turn up the concealed edge of counterflashings built into masonry or concrete walls not less than 6 mm (1/4 inch) and extend not less than 50 mm (2 inches) into the walls. Install counterflashing to provide a spring action against base flashing. Where bituminous base flashings are provided, extend down the counter flashing as close as practicable to the top of the cant strip. Factory form counter flashing to provide spring action against the base flashing.

3.1.13 Metal Reglets

Provide factory fabricated caulked type or friction type reglets with a minimum opening of 6 mm (1/4 inch) and a depth of 30 mm (1 1/4 inches), as approved.

3.1.13.1 Caulked Reglets

Provide with rounded edges and metal strap brackets or other anchors for securing to the concrete forms. Provide reglets with a core to protect them from injury during the installation. Provide built-up mitered corner pieces for internal and external angles. Wedge the flashing in the reglets with lead wedges every 450 mm (18 inches), caulked full and solid with an approved compound.

3.1.13.2 Friction Reglets

Provide with flashing receiving slots not less than 16 mm (5/8 inch) deep, 25 mm (one inch) jointing tongues, and upper and lower anchoring flanges installed at 600 mm (24 inches) maximum from snap lock receiver. Insert the flashing the full depth of the slot and lock by indentations made with a dull-pointed tool, wedges, and filled with a sealant. For friction reglets, install flashing snap lock receivers at 600 mm (24 inches) on center maximum. When the flashing has been inserted the full depth, caulk the slot and lock with wedges and fill with sealant.

3.1.14 Polyvinyl Chloride Reglets

Rigid polyvinyl chloride reglets ASTM D1784, Type II, Grade 1, Class 14333-D, 0.075 inch minimum thickness may be provided in lieu of metal reglets for temporary construction.

3.1.15 Gravel Stops and Fascias

Prefabricate in the shapes and sizes indicated and in lengths not less than

2400 mm (8 feet). Extend flange at least 100 mm (4 inches) onto roofing. Provide prefabricated, mitered corners internal and external corners. Install gravel stops and fascias after all plies of the roofing membrane have been applied, but before the flood coat of bitumen is applied. Prime roof flange of gravel stops and fascias on both sides with an asphalt primer. After primer has dried, set flange on roofing membrane and strip-in. Nail flange securely to wood nailer with large-head, barbed-shank roofing nails 38 mm (1.5 inches) long spaced not more than 75 mm (3 inches) on center, in two staggered rows.

3.1.15.1 Edge Strip

Hook the lower edge of fascias at least 20 mm (3/4 inch) over a continuous strip of the same material bent outward at an angle not more than 45 degrees to form a drip. Nail hook strip to a wood nailer at 150 mm (6 inches) maximum on center. Where fastening is made to concrete or masonry, use screws spaced 300 mm (12 inches) on center driven in expansion shields set in the concrete or masonry. Where horizontal wood nailers are slotted to provide for insulation venting, install strips to prevent obstruction of vent slots. Where necessary, install strips over 2 mm (1/16 inch) thick compatible spacer or washers.

3.1.15.2 Joints

Leave open the section ends of gravel stops and fascias 6 mm (1/4 inch) and backed with a formed flashing plate, mechanically fastened in place and lapping each section end a minimum of 100 mm (4 inch) set laps in plastic cement. Face nailing will not be permitted. Install prefabricated aluminum gravel stops and fascias in accordance with the manufacturer's printed instructions and details.

3.1.16 Metal Drip Edge

Provide a metal drip edge, designed to allow water run-off to drip free of underlying construction, at eaves and rakes prior to the application of roofing shingles. Apply directly on the wood deck at the eaves and over the underlay along the rakes. Extend back from the edge of the deck not more than 75 mm (3 inches) and secure with compatible nails spaced not more than250 mm (10 inches) on center along upper edge.

3.1.17 Gutters

The hung type of shape indicated and supported on underside by brackets that permit free thermal movement of the gutter. Provide gutters in sizes indicated complete with mitered corners, end caps, outlets, brackets, and other accessories necessary for installation. Bead with hemmed edge or reinforce the outer edge of gutter with a stiffening bar not less than 20 by 5 mm (3/4 by 3/16 inch) of material compatible with gutter. Fabricate gutters in sections not less than 2400 mm (8 feet). Lap the sections a minimum of 25 mm (one inch) in the direction of flow or provide with concealed splice plate 150 mm (6 inches) minimum. Join the gutters, other than aluminum, by riveted and soldered joints. Join aluminum gutters with riveted sealed joints. Provide expansion-type slip joints midway between outlets. Install gutters below slope line of the roof so that snow and ice can slide clear. Support gutters on adjustable hangers spaced not more than 750 mm (30 inches) on center, by continuous cleats , or by cleats spaced not less than 900 mm (36 inches) apart, as indicated. Adjust gutters to slope uniformly to outlets, with high points occurring midway between outlets. Fabricate hangers and fastenings from metals.

3.1.18 Downspouts

Space supports for downspouts according to the manufacturer's recommendation for the substrate. Types, shapes and sizes are indicated. Provide complete including elbows and offsets. Provide downspouts in approximately 3000 mm (10 foot) lengths. Provide end joints to telescope not less than 13 mm (1/2 inch) and lock longitudinal joints. Provide gutter outlets with wire ball strainers for each outlet. Provide strainers to fit tightly into outlets and be of the same material used for gutters. Keep downspouts not less than 25 mm (one inch) away from walls. Fasten to the walls at top, bottom, and at an intermediate point not to exceed 1500 mm (5 feet) on center with leader straps or concealed rack-and-pin type fasteners. Form straps and fasteners of metal compatible with the downspouts.

3.1.18.1 Terminations

Neatly fit into the drainage connection the downspouts terminating in drainage lines and fill the joints with a portland cement mortar cap sloped away from the downspout. Provide downspouts terminating in splash blocks with elbow-type fittings. Provide splash pans as specified.

3.1.19 Flashing for Roof Drains

Provide a 750 mm (30 inches) square sheet. Taper insulation to drain from 600 mm (24 inches) out. Set flashing on finished felts in a full bed of asphalt roof cement, ASTM D4586. Heavily coat the drain flashing ring with asphalt roof cement. Clamp the roof membrane, flashing sheet, and stripping felt in the drain clamping ring. Secure clamps so that felts and drain flashing are free of wrinkles and folds. Retrofit roof drains must conform to ANSI/SPRI RD-1.

3.1.20 Scuppers

Line interior of scupper openings with sheet metal. Extend the lining through and project outside of the wall to form a drip on the bottom edge and form to return not less than 25 mm (one inch) against the face of the outside wall at the top and sides. Fold outside edges under 13 mm (1/2 inch) on all sides. Provide the perimeter of the lining approximately 13 mm (1/2 inch) less than the perimeter of the scupper. Join the top and sides of the lining on the roof deck side to a closure flange by a locked and soldered joint. Join the bottom edge by a locked and soldered joint to the closure flange, where required, form with a ridge to act as a gravel stop around the scupper inlet. Provide surfaces to receive the scupper lining and coat with bituminous plastic cement.

3.1.21 Conductor Heads

Type indicated and fabricated of the same material as the downspouts. Set the depth of top opening equal to two-thirds of the width. Provide outlet tubes not less than 100 mm (4 inches) long. Flat-lock solder the seams. Where conductor heads are used in conjunction with scuppers, set the conductor a minimum of 50 mm (2 inches) wider than the scupper. Attach conductor heads to the wall with masonry fasteners, and loose-lock to provide conductor heads with screens of the same material. Securely fasten screens to the heads.

3.1.22 Splash Pans

Install splash pans where downspouts discharge on roof surfaces and at other locations as indicated. Unless otherwise shown, provide pans not less than 600 mm long by 450 mm wide (24 inches) long by 18 inches) wide with metal ribs across the bottom of the pan. Form the sides of the pan with vertical baffles not less than 25 mm (one inch) high in the front, and 100 mm (4 inches) high in the back doubled over and formed continuous with horizontal roof flanges not less than 100 mm (4 inches) wide. Bend the rear flange of the pan to contour of cant strip and extend up 150 mm (6 inches) under the side wall covering or to height of base flashing under counterflashing. Bed the pans and roof flanges in plastic bituminous cement and strip-flash as specified.

3.1.23 Open Valley Flashing

Provide valley flashing free of longitudinal seams, of width sufficient to extend not less than 150 mm (6 inches) under the roof covering on each side. Provide a 13 mm (1/2 inch) fold on each side of the valley flashing. Lap the sheets not less than 150 mm (6 inches) in the direction of flow and secure to roofing construction with cleats attached to the fold on each side. Nail the tops of sheets to roof sheathing. Space the cleats not more than 300 mm (12 inches) on center. Provide exposed flashing not less than 100 mm (4 inches) in width at the top and increase 25 mm (one inch) in width for each additional 2400 mm (8 feet) in length. Where the slope of the valley is one in 2.67 or less (4.5 inches or less per foot), or the intersecting roofs are on different slopes, provide an inverted V-joint, 25 mm (one inch) high, along the centerline of the valley; and extend the edge of the valley sheets 200 mm (8 inches) under the roof covering on each side.

Valley flashing for asphalt shingle roofs is specified in section 07 31 13 ASPHALT SHINGLES.

3.1.24 Eave Flashing

One piece in width, applied in 2400 to 3000 mm (8 to 10 foot) lengths with expansion joints spaced as specified in paragraph entitled "Expansion and Contraction." Provide a 20 mm (3/4 inch) continuous fold in the upper edge of the sheet to engage cleats spaced not more than 250 mm (10 inches) on center. Locate the upper edge of flashing not less than 450 mm (18 inches) from the outside face of the building, measured along the roof slope. Fold lower edge of the flashing over and loose-lock into a continuous edge strip on the fascia. Where eave flashing intersects metal valley flashing, secure with 25 mm (one inch) flat locked joints with cleats that are 250 mm (10 inches) on center.

3.1.25 Sheet Metal Covering on Flat, Sloped, or Curved Surfaces

Except as specified or indicated otherwise, cover and flash all minor flat, sloped, or curved surfaces such as crickets, bulkheads, dormers and small decks with metal sheets of the material used for flashing; maximum size of sheets, 375 by 455 mm (16 by 18 inches). Fasten sheets to sheathing with metal cleats. Lock seams and solder. Lock aluminum seams as recommended by aluminum manufacturer. Provide an underlayment of roofing felt for all sheet metal covering.

3.1.26 Expansion Joints

Provide expansion joints for roofs, walls, and floors as indicated. Provide expansion joints in continuous sheet metal at 12000 mm (40 foot) intervals for copper and stainless steel and at 9600 mm (32 foot) intervals for aluminum. Aluminum gravel stops and fascias which must have expansion joints at not more than 3600 mm (12 foot) spacing. Provide evenly spaced joints. Provide an additional joint where the distance between the last expansion joint and the end of the continuous run is more than half the required interval spacing. Conform to the requirements of Table I, unless otherwise indicated.

3.1.26.1 Roof Expansion Joints

Consist of curb with wood nailing members on each side of joint, bituminous base flashing, metal counterflashing, and metal joint cover. Bituminous base flashing is specified in Roofing Section. Provide counterflashing as specified in paragraph "Counterflashing," except as follows: Provide counterflashing with vertical leg of suitable depth to enable forming into a horizontal continuous cleat. Secure the inner edge to the nailing member. Make the outer edge projection not less than 25 mm (one inch) for flashing on one side of the expansion joint and be less than the width of the expansion joint plus 25 mm (one inch) for flashing on the other side of the joint. Hook the expansion joint cover over the projecting outer edges of counterflashing. Provide roof joint with a joint cover of the width indicated. Hook and lock one edge of the joint cover over the shorter projecting flange of the continuous cleat, and the other edge hooked over and loose locked with the longer projecting flange. Joints shall be as specified in Table II, unless otherwise indicated.

3.1.26.2 Floor and Wall Expansion Joints

Provide U-shape with extended flanges for expansion joints in concrete and masonry walls and in floor slabs.

3.1.27 Flashing at Roof Penetrations and Equipment Supports

Provide metal flashing for all pipes, ducts, and conduits projecting through the roof surface and for equipment supports, guy wire anchors, and similar items supported by or attached to the roof deck.

3.1.28 Single Pipe Vents

See Table I, footnote (d). Set flange of sleeve in bituminous plastic cement and nail 75 mm (3 inches) on center. Bend the top of sleeve over and extend down into the vent pipe a minimum of 50 mm (2 inches). For long runs or long rises above the deck, where it is impractical to cover the vent pipe with lead, use a two-piece formed metal housing. Set metal housing with a metal sleeve having a 100 mm (4 inches) roof flange in bituminous plastic cement and nailed 75 mm (3 inches) on center. Extend sleeve a minimum of 200 mm (8 inches) above the roof deck and lapped a minimum of 75 mm (3 inches) by a metal hood secured to the vent pipe by a draw band. Seal the area of hood in contact with vent pipe with an approved sealant.

3.1.29 Stepped Flashing

Stepped flashing shall be installed where sloping roofs surfaced with shingles abut vertical surfaces. Separate pieces of base flashing shall be placed in alternate shingle courses.

3.1.30 Copings

Provide coping using copper sheets 2400 or 3000 mm (8 or 10 feet) long joined by a 20 mm (3/4 inch) locked and soldered seam. Terminate outer edges in edge strips. Install with sealed lap, cover plate, and/or standing seam joints as indicated.

3.2 PAINTING

Field-paint sheet metal for separation of dissimilar materials.

3.2.1 Aluminum Surfaces

Shall be solvent cleaned and given one coat of zinc-molybdate primer and one coat of aluminum paint.

3.3 CLEANING

Clean exposed sheet metal work at completion of installation. Remove grease and oil films, handling marks, contamination from steel wool, fittings and drilling debris, and scrub-clean. Free the exposed metal surfaces of dents, creases, waves, scratch marks, and solder or weld marks.

3.4 REPAIRS TO FINISH

Scratches, abrasions, and minor surface defects of finish may be repaired in accordance with the manufacturer's printed instructions and as approved. Repair damaged surfaces caused by scratches, blemishes, and variations of color and surface texture. Replace items which cannot be repaired.

3.5 FIELD QUALITY CONTROL

Establish and maintain a Quality Control Plan for sheet metal used in conjunction with roofing to assure compliance of the installed sheet metalwork with the contract requirements. Remove work that is not in compliance with the contract and replace or correct. Include quality control, but not be limited to, the following:

a. Observation of environmental conditions; number and skill level of sheet metal workers; condition of substrate.

b. Verification that specified material is provided and installed.

c. Inspection of sheet metal work, for proper size(s) and thickness(es), fastening and joining, and proper installation.

3.5.1 Procedure

Submit for approval prior to start of roofing work. Include a checklist of points to be observed. Document the actual quality control observations and inspections. Furnish a copy of the documentation to the Contracting Officer at the end of each day.

TABLE I. SHEET METAL WEIGHTS, THICKNESSES, AND GAGES (METRIC)

Sheet Metal Items	Copper kilograms per square meter	Aluminum, mm	Stainless Steel, mm	Terne-Coated Stainless Steel, mm	Zinc-Coated Steel, mm
Building Expansion Joints					
Cover	4.9	0.81	0.38	0.38	0.6
Waterstop-bellows or flanged, U-type.	4.9	-	0.38	0.38	-
Covering on minor flat, pitched or curved surfaces	6.125	1.02	0.46	0.46	-
Downspouts and leaders	4.9	0.81	0.38	0.38	0.6
Downspout clips and anchors	-	1.02 clip 3.175 anchor	-	-	-
Downspout straps, 50 mm	14.7 (a)	1.52	1.27	-	-
Conductor heads	4.9	0.81	0.38	0.38	-
Scupper lining	6.125	0.81	0.38	0.38	-
Strainers, wire diameter or gage	4.0 gage	3.66 diameter	2.77 diameter	-	
Flashings:					
Base	6.125	1.02	0.46	0.46	0.6
Cap (Counter-flashing)	4.9	0.81	0.38	0.38	0.5
Eave	4.9	-	0.38	0.38	0.6
Spandrel beam	3.1	-	0.25	0.25	-
Bond barrier	4.9	-	0.38	0.38	-
Stepped	4.9	0.81	0.38	0.38	-

TABLE I. SHEET METAL WEIGHTS, THICKNESSES, AND GAGES (METRIC)

Sheet Metal Items	Copper kilograms per square meter	Aluminum, mm	Stainless Steel, mm	Terne-Coated Stainless Steel, mm	Zinc-Coated Steel, mm
Valley	4.9	0.81	0.38	0.38	-
Roof drain	4.9 (b)				
Pipe vent sleeve (d)					
Coping	4.9	-	-	-	-
Gravel stops and fascias:					
Extrusions	-	1.91	-	-	-
Sheets, corrugated	4.9	0.81	0.38	0.38	-
Sheets, smooth	6.125	1.27	0.46	0.46	0.6
Edge strip	7.35	1.27	0.635	-	-
Gutters:					
Gutter section	4.9	0.81	0.38	0.38	0.6
Continuous cleat	4.9	0.81	0.38	0.38	0.6
Hangers, dimensions	25 mm by 3 mm (a)	25 mm by 2 mm (c)	25 mm by 1 mm	-	-
Joint Cover plates (See Table II)	4.9	0.81	0.38	0.38	0.6
Reglets (c)	3.1	-	0.25	0.25	-
Splash pans	4.9	1.02	0.46	0.46	-
(a) Brass.					
(b) May be lead weighing 19.6 kilograms per square meter.					
(c) May be polyvinyl chloride.					
(d) 12.25 kilogram minimum lead sleeve with 100 mm flange. Where lead sleeve is impractical, refer to paragraph entitled "Single Pipe Vents" for optional material.					

TABLE I. SHEET METAL WEIGHTS, THICKNESSES, AND GAGES (ENGLISH)

Sheet Metal Items	Copper kilograms per square foot	Aluminum, inch	Stainless Steel, inch	Terne-Coated Stainless Steel, inch	Zinc-Coated Steel, U.S. Std. Gage
Building Expansion Joints					
Cover	16	.032	.015	.015	24
Waterstop-bellows or flanged, U-type.	16	-	.015	.015	-
Covering on minor flat, pitched or curved surfaces	20	.040	.018	.018	-
Downspouts and leaders	16	.032	.015	.015	24
Downspout clips and anchors	-	.040 clip .125 anchor	-	-	-
Downspout straps, 2-inch	48 (a)	.060	.050	-	-
Conductor heads	16	.032	.015	.015	-
Scupper lining	20	.032	.015	.015	-
Strainers, wire diameter or gage	No. 9 gage	.144 diameter	.109 diameter	-	
Flashings:					
Base	20	.040	.018	.018	24
Cap (Counter-flashing)	16	.032	.015	.015	26
Eave	16	-	.015	.015	24
Spandrel beam	10	-	.010	.010	-
Bond barrier	16	-	.015	.015	-
Stepped	16	.032	.015	.015	-

TABLE I. SHEET METAL WEIGHTS, THICKNESSES, AND GAGES (ENGLISH)

Sheet Metal Items	Copper kilograms per square foot	Aluminum, inch	Stainless Steel, inch	Terne-Coated Stainless Steel, inch	Zinc-Coated Steel, U.S. Std. Gage
Valley	16	.032	.015	.015	-
Roof drain	16 (b)				
Pipe vent sleeve (d)					
Coping	16	-	-	-	-
Gravel stops and fascias:					
Extrusions	-	.075	-	-	-
Sheets, corrugated	16	.032	.015	.015	-
Sheets, smooth	20	.050	.018	.018	24
Edge strip	24	.050	.025	-	-
Gutters:					
Gutter section	16	.032	.015	.015	24
Continuous cleat	16	.032	.015	.015	24
Hangers, dimensions	1 inch by 1/8 inch (a)	1 inch by . inch (c)	1 inch by .0 inch	-	-
Joint Cover plates (See Table II)	16	.032	.015	.015	24
Reglets (c)	10	-	.010	.010	-
Splash pans	16	.040	.018	.018	-
(a) Brass.					
(b) May be lead weighing 4 pounds per square foot.					
(c) May be polyvinyl chloride.					

TABLE I. SHEET METAL WEIGHTS, THICKNESSES, AND GAGES (ENGLISH)					
Sheet Metal Items	Copper kilograms per square foot	Aluminum, inch	Stainless Steel, inch	Terne-Coated Stainless Steel, inch	Zinc-Coated Steel, U.S. Std. Gage
(d) 2.5 pound minimum lead sleeve with 4 inch flange. Where lead sleeve is impractical, refer to paragraph entitled "Single Pipe Vents" for optional material.					

TABLE II. SHEET METAL JOINTS			
TYPE OF JOINT			
Item Designation	Copper, Terne-Coated Stainless Steel, Zinc-Coated Steel and Stainless Steel	Aluminum	Remarks
Joint cap for building expansion seam, cleated joint at roof	30 mm single lock, standing seam, cleated	30 mm single lock, standing	--
Flashings			
Base	25 mm 75 mm lap for expansion joint	25 mm flat locked, soldered; sealed; 75 mm lap for expansion joint	Aluminum producer's recommended hard setting sealant for locked aluminum joints. Fill each metal expansion joint with a joint sealing compound compound.
Cap-in reglet	75 mm lap	75 mm lap	Seal groove with joint sealing compound.
Reglets	Butt joint	--	Seal reglet groove with joint sealing compound.

TABLE II. SHEET METAL JOINTS

TYPE OF JOINT			
Item Designation	Copper, Terne-Coated Stainless Steel, Zinc-Coated Steel and Stainless Steel	Aluminum	Remarks
Eave	25 mm flat locked, cleated. 25 mm loose locked, sealed expansion joint, cleated.	25 mm flat locked, locked, cleated 25 mm loose locked, sealed expansion joints, cleated	Same as base flashing.
Stepped	75 mm lap	75 mm lap	--
Valley	150 mm lap cleated	150 mm lap cleated	--
Edge strip	Butt	Butt	--
Gravel stops:			
Extrusions	--	Butt with 13 mm space	Use sheet flashing beneath and a cover plate
Sheet, smooth	Butt with 6 mm space	Butt with 6 mm space	Use sheet flashing backup plate.
Sheet, corrugated	Butt with 6 mm space	Butt with 6 mm space	Use sheet flashing beneath and a cover plate or a combination unit
Gutters	40 mm lap, riveted and soldered	25 mm flat locked riveted and sealed	Aluminum producers recommended hard setting sealant for locked aluminum joints.
(a) Provide a 75 mm lap elastomeric flashing with manufacturer's recommended sealant.			
(b) Seal Polyvinyl chloride reglet with manufacturer's recommended sealant.			

TABLE II. SHEET METAL JOINTS			
TYPE OF JOINT			
Item Designation	Copper, Terne-Coated Stainless Steel, Zinc-Coated Steel and Stainless Steel	Aluminum	Remarks
Joint cap for building expansion seam, cleated joint at roof	1.25 inch single lock, standing seam, cleated	1.25 inch single lock, standing	--
Flashings			
Base	One inch 3 inch lap for expansion joint	One inch flat locked, soldered; sealed; 3 inch lap for expansion joint	Aluminum producer's recommended hard setting sealant for locked aluminum joints. Fill each metal expansion joint with a joint sealing compound compound.
Cap-in reglet	3 inch lap	3 inch lap	Seal groove with joint sealing compound.
Reglets	Butt joint	--	Seal reglet groove with joint sealing compound.
Eave	One inch flat locked, cleated. One inch loose locked, sealed expansion joint, cleated.	One inch flat locked, locked, cleated one inch loose locked, sealed expansion joints, cleated	Same as base flashing.
Stepped	3 inch lap	3 inch lap	--
Valley	6 inch lap cleated	6 inch lap cleated	--
Edge strip	Butt	Butt	--
Gravel stops:			

TABLE II. SHEET METAL JOINTS			
TYPE OF JOINT			
Item Designation	Copper, Terne-Coated Stainless Steel, Zinc-Coated Steel and Stainless Steel	Aluminum	Remarks
Extrusions	--	Butt with 1/2 inch space	Use sheet flashing beneath and a cover plate
Sheet, smooth	Butt with 1/4 inch space	Butt with 1/4 inch space	Use sheet flashing backup plate.
Sheet, corrugated	Butt with 1/4 inch space	Butt with 1/4 inch space	Use sheet flashing beneath and a cover plate or a combination unit
Gutters	1.5 inch lap, riveted and soldered	One inch flat locked riveted and sealed	Aluminum producers recommended hard setting sealant for locked aluminum joints.
(a) Provide a 3 inch lap elastomeric flashing with manufacturer's recommended sealant.			
(b) Seal Polyvinyl chloride reglet with manufacturer's recommended sealant.			

-- End of Section --

SECTION 07 61 14.00 20

STEEL STANDING SEAM ROOFING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI SG03-3	(2002; Suppl 2001-2004; R 2008) Cold-Formed Steel Design Manual Set

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE Z359.1	(2007) Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A1011/A1011M	(2014) Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
ASTM A182/A182M	(2013a) Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A792/A792M	(2010) Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by

	the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D2244	(2011) Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D2247	(2011) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D4214	(2007) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D522/D522M	(2014) Mandrel Bend Test of Attached Organic Coatings
ASTM D523	(2014) Standard Test Method for Specular Gloss
ASTM D714	(2002; R 2009) Evaluating Degree of Blistering of Paints
ASTM D968	(2005; R 2010) Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM E1592	(2005; R 2012) Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G152	(2013) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G153	(2013) Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils

1.2 DEFINITIONS

1.2.1 Field-Formed Seam

Seams of panels so configured that when adjacent sheets are installed the seam is sealed utilizing mechanical or hand seamers. Crimped (45 degree bend), roll formed (180 degree bend), double roll formed (2 - 180 degree bends), and roll and lock systems are types of field-formed seam systems.

1.2.2 Snap Together Seam

Panels so configured that the male and female portions of the seam interlock through the application of foot pressure or tamping with a mallet. Snap-on cap configurations are a type of snap together system.

1.2.3 Pre-Formed

Formed to the final, less field-formed seam, profile and configuration in the factory.

1.2.4 Field-Formed

Formed to the final, less field-formed seam, profile and configuration at the site of work prior to installation.

1.2.5 Roofing System

The roofing system is defined as the assembly of roofing components, including roofing panels, flashing, fasteners, and accessories which, when assembled properly result in a watertight installation.

1.3 SYSTEM DESCRIPTION

1.3.1 Design Requirements

a. Panels shall be continuous lengths up to manufacturer's standard longest lengths, with no joints or seams, except where indicated or specified. Ribs of adjoining sheets shall be in continuous contact from eave to ridge. Individual panels of snap together type systems shall be removable for replacement of damaged material.

b. There shall be no exposed or penetrating fasteners except where shown on approved shop drawings. Fasteners into steel shall be stainless steel, zinc cast head, or cadmium plated steel screws inserted into predrilled holes. There shall be a minimum of two fasteners per clip. Single fasteners will be allowed when supporting structural members are prepunched or predrilled.

c. Snap together type systems shall have a capillary break and a positive side lap locking device. Field-formed seam type systems shall be mechanically locked closed by the manufacturer's locking tool. The seam shall include a continuous factory applied sealant when required by the manufacturer to withstand the wind loads specified.

d. Roof panel anchor clips shall be concealed and designed to allow for longitudinal thermal movement of the panels, except where specific fixed points are indicated. Provide for lateral thermal movement in panel configuration or with clips designed for lateral and longitudinal movement.

1.3.2 Design Conditions

The system shall be designed to resist positive and negative loads specified herein in accordance with the AISI SG03-3. Panels shall support walking loads without permanent distortion or telegraphing of the structural supports.

1.3.2.1 Wind Uplift

The design uplift pressures for the roof system is shown on the contract drawings. Roof system and attachments shall resist the wind loads as indicated. The design uplift force for each connection assembly shall be that pressure given for the area under consideration, multiplied by the tributary load area of the connection assembly, and multiplied by the appropriate factor of safety, as follows:

a. Single fastener in a connection: 3.0

b. Two or more fasteners in each connection: 2.25

1.3.2.2 Roof Live Loads

Loads shall be applied on the horizontal projection of the roof structure. The minimum roof design live load shall be one kPa (20 psf).

1.3.2.3 Thermal Movement

System shall be capable of withstanding thermal movement based on a temperature range of 5 degrees C (41 degrees F) during the life of the structure.

1.3.2.4 Deflection

Panels shall be capable of supporting design loads between unsupported spans with deflection of not greater than L/180 of the span.

1.3.3 Structural Performance

The structural performance test methods and requirements of the Standing Seam Roofing Systems (SSRS) shall be in accordance with ASTM E1592.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roofing; G

Submit roofing drawings to supplement the instructions and diagrams. Drawings shall include design and erection drawings containing an isometric view of the roof showing the design uplift pressures and dimensions of edge, ridge and corner zones; and show typical and special conditions including flashings, materials and thickness, dimensions, fixing lines, anchoring methods, sealant locations, sealant tape locations, fastener layout, sizes, and spacing, terminations, penetrations, attachments, and provisions for thermal movement. Details of installation shall be in accordance with the manufacturer's Standard Instructions and details or the SMACNA 1793. Prior to submitting shop drawings, have drawings reviewed and approved by the manufacturer's technical engineering department.

SD-03 Product Data

Roofing panels

Attachment clips

Closures

Accessories

Fasteners

Sealants

Insulation, including joint sealing measures for vapor barrier facing

Sample warranty certificate

Submit for materials to be provided. Submit data sufficient to indicate conformance to specified requirements.

SD-04 Samples

Roofing panel

Submit a 300 mm (12 inch) long by full width section of typical panel.

For color selection, submit 50 by 100 mm (2 by 4 inch) metal samples in color, finish and texture specified.

Accessories

Submit each type of accessory item used in the project including, but not limited to each type of anchor clip, closure, fastener, and leg clamp.

Sealants

Intermediate Support Section

Submit full size samples of each intermediate support section, 300 mm (12 inches) long.

SD-05 Design Data

Design calculations

SD-06 Test Reports

Field Inspection; G

Submit manufacturer's technical representative's field inspection reports as specified in paragraph entitled "Manufacturer's Field Inspection."

Structural performance tests

Finish tests

SD-07 Certificates

Manufacturer's Technical Representative's Qualifications

Statement of Installer's Qualifications

Submit documentation from roofing manufacturer proving the manufacturer's technical representative meets below specified requirements. Include name, address, telephone number, and experience record.

Submit documentation proving the installer is factory-trained, has the specified experience, and authorized by the manufacturer to install the products specified.

Coil stock compatibility

Provide certification of coil compatibility with roll forming machinery to be used for forming panels without warping, waviness, and rippling not part of panel profile; to be done without damage, abrasion or marking of finish coating.

SD-08 Manufacturer's Instructions

Installation manual

Submit manufacturers printed installation manual, instructions, and standard details.

SD-11 Closeout Submittals

Information card

1.5 DESIGN CALCULATIONS

Provide design calculations prepared by a professional engineer specializing in structural engineering verifying that system supplied and any additional framing meets design load criteria indicated. Coordinate calculations with manufacturer's test results. Include calculations for:

Wind load uplift design pressure at roof locations specified in paragraph entitled "Wind Uplift."

Clip spacing and allowable load per clip.

Fastening of clips to structure or intermediate supports.

Intermediate support spacing and framing and fastening to structure when required.

Allowable panel span at anchorage spacing indicated.

Safety factor used in design loading.

Governing code requirements or criteria.

Edge and termination details.

1.6 QUALITY ASSURANCE

1.6.1 Preroofing Conference

After submittals are received and approved but before roofing work, including associated work, is preformed, the Contractor shall hold a preroofing conference to review the following:

a. The drawings and specifications

b. Procedure for on site inspection and acceptance of the roofing substrate and pertinent structural details relating to the roofing system

c. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing

d. Safety requirements

The preroofing conference shall be attended by the Contractor and personnel directly responsible for the roofing installation, and the roofing manufacturer's technical representative. Conflicts among those attending the preroofing conference shall be resolved and confirmed in writing before roofing work, including associated work, is begun.

1.6.2 Manufacturer

The SSMRS shall be the product of a metal roofing industry - recognized manufacturer who has been in the practice of manufacturing SSMRS for a period of not less than 5 years and who has been involved in at least 5 projects similar in size and complexity to this project.

1.6.3 Manufacturer's Technical Representative

The representative shall have authorization from manufacturer to approve field changes and be thoroughly familiar with the products and with installations in the geographical area where construction will take place. The manufacturer's representative shall be an employee of the manufacturer with at least 5 years experience in installing the roof system. The representative shall be available to perform field inspections and attend meetings as required herein, and as requested by the Contracting Officer.

1.6.4 Installer's Qualifications

The roofing system installer shall be factory-trained, approved by the metal roofing system manufacturer to install the system, and shall have a minimum of three years experience as an approved applicator with that manufacturer. The applicator shall have applied five installations of similar size and scope as this project within the previous 3 years.

1.6.5 Single Source

Roofing panels, clips, closures, and other accessories shall be standard products of the same manufacturer; shall be the latest design by the manufacturer; and shall have been designed by the manufacturer to operate as a complete system for the intended use.

1.6.6 Laboratory Tests For Panel Finish

The term "appearance of base metal" refers to the metal coating on steel. Panels shall meet the following test requirements:

a. Formability Test: When subjected to a 180 degree bend over a 3 mm (1/8 inch) diameter mandrel in accordance with ASTM D522/D522M, exterior coating film shall show only slight microchecking and no loss of adhesion.

b. Accelerated Weathering Test: Withstand a weathering test for a minimum of 2000 hours in accordance with ASTM G152 and ASTM G153, Method 1 without cracking, peeling, blistering, loss of adhesion of the protective coating, or corrosion of the base metal. Protective coating that can be readily removed from the base metal with a penknife blade or similar instrument shall be considered to indicate loss of adhesion.

c. Chalking Resistance: After the 2000-hour weatherometer test, exterior coating shall not chalk greater than No. 8 rating when measured in accordance with ASTM D4214 test procedures.

d. Color Change Test:

   After the 3000-hour weatherometer test, exterior coating color change shall not exceed NBS units when measured in accordance with ASTM D2244 test procedure.

e. Salt Spray Test: Withstand a salt spray test for a minimum of 1000 hours in accordance with ASTM B117, including the scribe requirement in the test. Immediately upon removal of the panel from the test, the coating shall receive a rating of 10, no blisters in field as determined by ASTM D714; and an average rating of 6, 3 mm or 7, 2 mm (1/8 inch or 1/16 inch) failure at scribe, as determined by ASTM D1654. Rating Schedule No. 1.

f. Abrasion Resistance Test for Color Coating: When subjected to the falling sand test in accordance with ASTM D968, coating system shall withstand a minimum of 100 liters of sand per mil thickness before appearance of base metal.

g. Humidity Test: When subjected to a humidity cabinet test in accordance with ASTM D2247 for 1000 hours, a scored panel shall show no signs of blistering, cracking, creepage, or corrosion.

h. Gloss Test: The gloss of the finish shall be 30 plus or minus 5 at an angle of 60 degrees, when measured in accordance with ASTM D523.

i. Glare Resistance Test:

Surfaces of panels that will be exposed to the exterior shall have a specular reflectance of not more than 10 when measured in accordance with ASTM D523 at an angle of 85 degrees. Specular reflectance may be obtained with striations or embossing. Requirements specified under "Formability Test" will be waived if necessary to conform to this requirement.

1.7 WARRANTY

Furnish manufacturer's no-dollar-limit materials and workmanship warranty for the roofing system. The warranty period shall be not less than 20 years from the date of Government acceptance of the work. The warranty shall be issued directly to the Government. The warranty shall provide that if within the warranty period the metal roofing system becomes non-watertight or shows evidence of corrosion, perforation, rupture or excess weathering due to deterioration of the roofing system resulting from defective materials or installed workmanship the repair or replacement of the defective materials and correction of the defective workmanship shall be the responsibility of the roofing system manufacturer. Repairs that become necessary because of defective materials and workmanship while roofing is under warranty shall be performed within 7 days after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within the specified period of time will constitute grounds for having the repairs performed by others and the cost billed to the manufacturer. The Contractor shall also provide a 2 year contractor installation warranty.

1.8 DELIVERY, STORAGE AND HANDLING

Deliver, store, and handle preformed panels, bulk roofing products and other manufactured items in a manner to prevent damage or deformation.

1.8.1 Delivery

Provide adequate packaging to protect materials during shipment. Crated materials shall not be uncrated until ready for use, except for inspection. Immediately upon arrival of materials at the jobsite, inspect materials for damage, dampness, and staining. Damaged or permanently stained materials that cannot be restored to like-new condition shall be replaced with satisfactory material. If materials are wet, remove the moisture and re-stack and protect the panels until used.

1.8.2 Storage

Stack materials on platforms or pallets and cover with tarpaulins or other suitable weathertight covering which prevents water trapping or condensation. Store materials so that water which might have accumulated during transit or storage will drain off. Do not store the panels in contact with materials that might cause staining, such as mud, lime, cement, fresh concrete or chemicals. Protect stored panels from wind damage.

1.8.3 Handling

Handle material carefully to avoid damage to surfaces, edges and ends.

PART 2 PRODUCTS

2.1 ROOFING PANELS

Panels shall have interlocking ribs for securing adjacent sheets. System for securing the roof covering to structural framing members shall be concealed clip fastening system with no fasteners penetrating the panels except at the ridge or eave, rakes, penetrations, and end laps. Backing plates and ends of panels at end laps shall be predrilled or prepunched; factory prepare ends of panels to be lapped by trimming part of seam, die-setting or swaging ends of panels. Length of sheets shall be sufficient to cover the entire length of any unbroken roof slope when such slope is 9 meters (30 feet) or less. When length of run exceeds 9 meters (30 feet), each sheet in the run shall extend over two or more spans. Sheets longer than 9 meters (30 feet) may be furnished if approved by the Contracting Officer. Width of sheets shall provide not less than 300 mm (12 inches) of coverage in place. Height of corrugations of adjacent roof sheets shall be not less than 45, 57, 76 mm (1.75, 2.25, 3.0 inch). Make provisions for expansion and contraction at either ridge or eave, consistent with the type of system to be used. Panels from coil stock shall be formed without warping, waviness or ripples not part of the panel profile and shall be free of damage to the finish coating system.

2.1.1 Material

Zinc-coated steel conforming to ASTM A653/A653M, Z27 (G90) or KS D 3506 coating designation or aluminum-zinc alloy coated steel conforming to ASTM A792/A792M or KS D 3506, AZ 165(55) coating. Minimum thickness to be 0.6 mm (0.023 inch) thick (24 gage) minimum except when mid field of roof is subject to design wind uplift pressures of 3 kPa (60 psf) or greater, entire roof system shall have a minimum thickness of 0.8 mm (0.030 inch) (22 gage). Prior to shipment, treat mill finish panels with a passivating chemical and oil to inhibit the formation of oxide corrosion products. Dry, retreat, and re-oil panels that have become wet during shipment or storage but have not started to oxidize.

2.1.2 Texture

Smooth or Smooth with raised intermediate ribs for added stiffness.

2.1.3 Finish

Factory color finish.

2.1.3.1 Factory Color Finish

Provide factory applied, thermally cured coating to exterior and interior of metal roof and wall panels and metal accessories. Provide exterior finish top coat of 70 percent resin polyvinylidene fluoride with not less than 0.005 mm, 0.020 mm (0.2 mil, 0.8 mil) dry film thickness. Provide exterior primer standard with panel manufacturer with not less than 0.005 mm, 0.020 mm (0.2 mil, 0.8 mil) dry film thickness. Interior finish shall consist of the same coating and dry film thickness as the exterior coating. Provide exterior and interior coating meeting test requirements specified below. Tests shall have been performed on the same factory finish and thickness provided. Provide clear factory edge coating on all factory cut or unfinished edges.

2.2 INTERMEDIATE SUPPORTS

Fabricate panel subgirts, subpurlins, T-bars, Z-bars and tracks from galvanized steel conforming to ASTM A653/A653M, Z275 (G90), Grade D, 1.6 mm thick (16 gage) and heavier, Grade A, 1.3 mm thick (18 gage) and lighter; or steel conforming to ASTM A36/A36M, ASTM A1011/A1011M , or ASTM A1008/A1008M prime painted with zinc-rich primer. Size, shape, thickness and capacity as required to meet the load, insulation thicknessand deflection criteria specified.

2.3 ATTACHMENT CLIPS

Fabricate clips from ASTM A1011/A1011M, or ASTM A1008/A1008M steel hot-dip galvanized in accordance with ASTM A653/A653M, Z275 (G 90), or Series 300 stainless steel. Size, shape, thickness and capacity as required to meet the load, insulation thickness and deflection criteria specified.

2.4 ACCESSORIES

Sheet metal flashings, gutters, downspouts, trim, moldings, closure strips, pre-formed crickets, caps, equipment curbs, and other similar sheet metal accessories used in conjunction with preformed metal panels shall be of the same material as used for the panels. Provide metal accessories with a factory color finish to match the roofing panels, except that such items which will be concealed after installation may be provided without the finish if they are stainless steel. Metal shall be of a thickness not less than that used for the panels. Thermal spacer blocks and other thermal barriers at concealed clip fasteners shall be as recommended by the manufacturer except that wood spacer blocks are not allowed.

2.4.1 Closures

2.4.1.1 Rib Closures

Corrosion resisting steel, closed-cell or solid-cell synthetic rubber, neoprene or polyvinyl chloride pre-molded to match configuration of rib opening. Material for closures shall not absorb water.

2.4.1.2 Ridge Closures

Metal-clad foam or metal closure with foam secondary closure matching panel configuration for installation on surface of roof panel between panel ribs at ridge and headwall roof panel flashing conditions and terminations. Foam material shall not absorb water.

2.4.2 Fasteners

Zinc-coated steel, corrosion resisting steel, zinc cast head, or nylon capped steel, type and size specified below or as otherwise approved for the applicable requirements. Design the fastening system to withstand the design loads specified. Exposed fasteners shall be gasketed or have gasketed washers on the exterior side of the covering to waterproof the penetration. Washer material shall be compatible with the covering; have a minimum diameter of 10 mm (3/8 inch) for structural connections; and gasketed portion of fasteners or washers shall be neoprene or other equally durable elastomeric material approximately 3 mm (1/8 inch) thick.

2.4.2.1 Screws

Not smaller than 4.75 mm (No. 14) diameter if self-tapping type and not smaller than 4 mm (No. 12) diameter if self-drilling and self-tapping.

2.4.2.2 Bolts

Not smaller than 6 mm (1/4 inch) diameter, shouldered or plain shank as required, with proper nuts.

2.4.2.3 Automatic End-Welded Studs

Automatic end-welded studs shall be shouldered type with a shank diameter of not smaller than 5 mm (3/16 inch) and cap or nut for holding covering against the shoulder.

2.4.2.4 Explosive Driven Fasteners

Fasteners for use with explosive actuated tools shall have a shank diameter of not smaller than 4 mm (0.145 inch) with a shank length of not smaller than 12.7 mm (1/2 inch) for fastening to steel and not smaller than 25 mm (one inch) for fastening to concrete.

2.4.2.5 Rivets

Blind rivets shall be stainless steel with 3 mm (1/8 inch) nominal diameter shank. Rivets shall be threaded stem type if used for other than the fastening of trim. Rivets with hollow stems shall have closed ends.

2.4.3 Sealants

Elastomeric type containing no oil or asphalt. Exposed sealant shall cure to a rubber-like consistency. Concealed sealant shall be the non-hardening type. Seam sealant shall be factory-applied, non-skinning, non-drying, and shall conform to the roofing manufacturer's recommendations. Silicone-based sealants shall not be used in contact with finished metal panels and components unless approved otherwise by the Contracting Officer.

2.4.4 GASKETS AND INSULATING COMPOUNDS

Nonabsorptive and suitable for insulating contact points of incompatible materials. Insulating compounds shall be nonrunning after drying.

2.5 THERMAL INSULATION

Flexible blanket, rigid, or semi-rigid faced with a flexible vapor retarder. Insulation and facing shall have a flame-spread rating of 50 or less in accordance with ASTM E84. Vapor retarder facing shall have a permeance rating of 0.05 perm or less. Provide a thermal resistance "R" value of as indicated. Facings shall be factory-applied.

2.6 LINER PANELS

Fabricate liner panels of the same material as roof panels, and formed or patterned to prevent waviness and distortion. Liner panels shall have a factory applied, one mil thick minimum painted coating on the inside face and a prime coat on the liner side.

2.7 FALL PROTECTION SYSTEM

Leave in place fall protection anchorage, horizontal lifeline, or equivalent protection system conforming to ASSE/SAFE Z359.1 and EM 385-1-1. Systems shall be designed and installed under the supervision of a qualified person in fall protection as specified in section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS, and shall be identified by signage stating the capacity of the anchorage (strength and number of persons who may be tied-off to it at any one time). Exposed structural components and hardware shall be hot dip galvanized or corrosion resistant steel conforming to ASTM A500/A500M, ASTM A36/A36M, or ASTM A182/A182M, as applicable.

PART 3 EXECUTION

3.1 EXAMINATION

Examine surfaces to receive standing seam metal roofing and flashing. Ensure that surfaces are plumb and true, clean, even, smooth, as dry and free from defects and projections which might affect the installation.

3.2 PROTECTION FROM CONTACT WITH DISSIMILAR MATERIALS

3.2.1 Cementitious Materials

Paint metal surfaces which will be in contact with mortar, concrete, or other masonry materials with one coat of alkali-resistant coating such as heavy-bodied bituminous paint.

3.2.2 Contact with Wood

Where metal will be in contact with wood or other absorbent material subject to wetting, seal joints with sealing compound and apply one coat of heavy-bodied bituminous paint.

3.3 INSTALLATION

Install in accordance with the approved manufacturer's erection instructions, shop drawings, and diagrams. Panels shall be in full and firm contact with attachment clips. Where prefinished panels are cut in the field, or where any of the factory applied coverings or coatings are abraded or damaged in handling or installation, they shall, after necessary repairs have been made with material of the same color as the weather coating, be approved before being installed. Seal completely openings through panels. Correct defects or errors in the materials. Replace materials which cannot be corrected in an approved manner with nondefective materials. Provide molded closure strips where indicated and where necessary to provide weathertight construction. Use shims as required to ensure attachment clip line is true. Use a spacing gage at each row of panels to ensure that panel width is not stretched or shortened.

3.3.1 Roof Panels

Apply roofing panels with the standing seams parallel to the slope of the roof. Provide roofing panels in longest practical lengths from ridge to eaves (top to eaves on shed roofs), with no transverse joints except at the junction of ventilators, curbs, skylights, chimneys, and similar openings. Install flashing to assure positive water drainage away from roof penetrations. Locate panel end laps such that fasteners do not engage supports or otherwise restrain the longitudinal thermal movement of panels. Form field-formed seam type system seams in the field with an automatic mechanical seamer approved by the manufacturer. Attach panels to the structure with concealed clips incorporated into panel seams. Clip attachment shall allow roof to move independently of the structure, except at fixed points as indicated.

3.3.2 Insulation Installation

Insulation shall be installed between covering and supporting members to present a neat appearance. Fold and staple seams unless approved otherwise by the Contracting Officer.

3.3.2.1 Rigid or Semi-Rigid Insulation

Install in areas where insulation is exposed to view. Fasten securely without loose joints or unsightly sags.

3.3.2.2 Blanket Insulation

May be used in concealed locations. Lap facing at joints and fasten in a manner that will provide tight joints.

3.3.3 Flashings

Provide flashing, related closures and accessories as indicated and as necessary to provide a weathertight installation. Install flashing to ensure positive water drainage away from roof penetrations. Flash and seal the roof at the ridge, eaves and rakes, and projections through the roof. Place closure strips, flashing, and sealing material in an approved manner that will assure complete weathertightness. Details of installation which are not indicated shall be in accordance with the SMACNA 1793, panel manufacturer's approved printed instructions and details, or the approved shop drawings. Allow for expansion and contraction of flashing.

3.3.4 Flashing Fasteners

Fastener spacings shall be in accordance with the panel manufacturer's recommendations and as necessary to withstand the design loads indicated. Install fasteners in roof valleys as recommended by the manufacturer of the panels. Install fasteners in straight lines within a tolerance of 12.7 mm (1/2 inch) in the length of a bay. Drive exposed penetrating type fasteners normal to the surface and to a uniform depth to seat gasketed washers properly and drive so as not to damage factory applied coating. Exercise extreme care in drilling pilot holes for fastenings to keep drills perpendicular and centered. Do not drill through sealant tape. After drilling, remove metal filings and burrs from holes prior to installing fasteners and washers. Torque used in applying fasteners shall not exceed that recommended by the manufacturer. Remove panels deformed or otherwise damaged by over-torqued fastenings, and provide new panels.

3.3.5 Rib and Ridge Closure/Closure Strips

Set closure/closure strips in joint sealant material and apply sealant to mating surfaces prior to adding panel.

3.4 PROTECTION OF APPLIED ROOFING

Do not permit storing, walking, wheeling, and trucking directly on applied roofing materials. Provide temporary walkways, runways, and platforms of smooth clean boards or planks as necessary to avoid damage to applied roofing materials, and to distribute weight to conform to indicated live load limits of roof construction.

3.5 CLEANING

Clean exposed sheet metal work at completion of installation. Remove metal shavings, filings, nails, bolts, and wires from roofs. Remove grease and oil films, excess sealants, handling marks, contamination from steel wool, fittings and drilling debris and scrub the work clean. Exposed metal surfaces shall be free of dents, creases, waves, scratch marks, solder or weld marks and damage to the finish coating.

3.6 MANUFACTURER'S FIELD INSPECTION

Manufacturer's technical representative shall visit the site as necessary during the installation process to assure panels, flashings, and other components are being installed in a satisfactory manner. Manufacturer's technical representative shall perform a field inspection during the first 20 squares of roof panel installation and at substantial completion prior to issuance of warranty, as a minimum, and as otherwise requested by the Contracting Officer. Additional inspections shall not exceed one for 100 squares of total roof area with the exception that follow-up inspections of previously noted deficiencies or application errors shall be performed as requested by the Contracting Officer. Each inspection visit shall include a review of the entire installation to date. After each inspection, a report, signed by the manufacturer's technical representative, shall be submitted to the Contracting Officer noting the overall quality of work, deficiencies and any other concerns, and recommended corrective actions in detail. Notify Contracting Officer a minimum of 2 working days prior to site visit by manufacturer's technical representative.

3.7 COMPLETED WORK

Completed work shall be plumb and true without oil canning, dents, ripples, abrasion, rust, staining, or other damage detrimental to the performance or aesthetics of the completed roof assembly.

3.8 INFORMATION CARD

For each roofing installation, provide a typewritten card, laminated in plastic and framed for interior display or a photoengraved 0.8mm (0.032 inch) thick aluminum card for exterior display. Card to be 220 by 280 mm (8 1/2 by 11 inch) minimum and contain the information listed on Form 1 at end of this section. Install card near point of access to roof, or where indicated.

3.9 FORM ONE

FORM 1 - PREFORMED STEEL STANDING SEAM ROOFING SYSTEM COMPONENTS

1. Contract Number:

2. Building Number & Location:

3. NAVFAC Specification Number:

4. Deck/Substrate Type:

5. Slopes of Deck/Roof Structure:

6. Insulation Type & Thickness:

7. Insulation Manufacturer:

8. Vapor Retarder: ( )Yes ( )No

9. Vapor Retarder Type:

10. Preformed Steel Standing Seam Roofing Description:

a. Manufacturer (Name, Address, & Phone No.):
b. Product Name: c. Width: d. Gage:
e. Base Metal: f. Method of Attachment:

11. Repair of Color Coating:

a. Coating Manufacturer (Name, Address & Phone No.):
b. Product Name:
c. Surface Preparation:
d. Recoating Formula:
e. Application Method:

12. Statement of Compliance or Exception:_________________________________
____
____

13. Date Roof Completed:

14. Warranty Period: From_______________ To_______________

15. Roofing Contractor (Name & Address):

16. Prime Contractor (Name & Address):

Contractor's Signature _________________________ Date:

Inspector's Signature _________________________ Date:

---END OF SECITON---

SECTION 07 72 00

ROOF VENTILATORS, GRAVITY-TYPE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 6701	(2012) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6759	(2011) Aluminum and Aluminum Alloy Extruded Shapes

1.2 DESIGN REQUIREMENTS

Design ventilators for use with the specific type of project roofing system, and to provide uniform and continuous air flow. Ventilator design shall provide protection against rain and snow, and shall be provided with a continuous weep along the bottom of both sides of wind band. Units shall be self-cleaning by the action of the elements, and shall have provisions for carrying water and normal wind-transported soil matter to the outside. Design units for wind speeds of not less than 36 m/second (80 mph) in accordance with ASCE 7. Ventilators shall be free of internal obstructions or moving parts which will require maintenance, and shall be complete with type of mounting indicated on drawings.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roof Ventilators

1.4 QUALITY ASSURANCE

Manufacturer shall specialize in design and manufacture of the type of roof ventilators specified in this section, and shall have a minimum of 5 years of documented successful experience. Provide a ventilator installer experienced in the installation of ventilator types specified.

1.5 DELIVERY, STORAGE, AND HANDLING

Roof ventilators shall be cartoned or crated prior to shipment. Protect ventilators from moisture and damage. Remove damaged items from the site.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Aluminum Extrusions

Aluminum extrusions shall be alloy 6063, temper T5 in compliance with ASTM B221M ASTM B221 or KS D 6759.

2.1.2 Aluminum Sheets

Aluminum sheets shall be alloy 5005, temper H15 or alloy 3003, temper H14 in compliance with ASTM B209M ASTM B209 or KS D 6701.

2.1.3 Galvanized Steel Sheets

Steel sheets shall be commercial quality, zinc-coated steel (hot-dip galvanized) of quality established by ASTM A653/A653M or KS D 3506, minimum G90 coating thickness.

2.2 RIDGE VENTILATORS

Provide roof ridge ventilators fabricated of galvanized steel or aluminum, and assembled to any desired length. Continuous-run ridge ventilators shall be connected with splice plates of type which will telescope together and not require fasteners, soldering or welding. Provide ventilators with manually-operated single-leaf dampers complete with accessories to meet design and performance requirements. Dampers and air shafts shall be complete with urethane gasketing for extra-tight enclosures. Provide metal closure strips, which match the panel roof rib contours, to close out weather and provide a secure seat for ventilators. Insect screens shall be provided.

2.3 STATIONARY VENTILATORS

Provide stationary roof ventilators fabricated of galvanized steel or aluminum with seamless spun conical-shaped weather cap, and having straight-through drainage for eliminating the possibility of air-borne debris collecting in the ventilator openings. Insect screens shall be provided.

2.4 TURBINE VENTILATORS

Provide turbine ventilators fabricated of galvanized steel or aluminum sheets, complete with sensitive ball-bearing action to enable the slightest motion of air to move the rotor head where suction is maintained at low wind velocities. Ventilators shall have 360 degree operating surface to assure access of wind currents regardless of wind velocities. Rotor head shall be anchored to prevent head from lifting or jumping off the rotor in high winds. Rotor crown plate shall be seamless. Insect screens shall be provided.

2.4.1 Dampers

Turbine ventilators shall be provided with dampers manually-operated with direct pull-chain or rack and pinion and push-button control electric gear motor-operated dampers .

2.4.2 Rotor Shaft

Rotor shaft bearings shall be entirely shielded in corrosion-resistant aluminum casing. Bearings shall be pre-lubricated and shall have life-time warranty. Bearings shall be at top and bottom to assure accurate alignment. Shaft and bearings shall be easily replaceable as a unit. Rotor collar shall be rolled and welded.

2.5 FABRICATION

Ventilators shall be fabricated in accordance with approved shop drawings. Welds, soldered seams, rivets and fasteners shall be clean, secure, watertight, and smooth. Edges shall be wired or beaded, where necessary, to ensure rigidity. Joints between sections shall be watertight and shall allow for expansion and contraction. Galvanic action between different metals in direct contact shall be prevented by nonconductive separators.

2.6 CURB BASES

Ventilator bases for curb-mounted installations shall be of size indicated on drawings, and shall be designed specifically for the type of ventilator and roofing system approved for this project. Curb bases shall be factory-formed and flashed for a watertight installation. Curb bases shall be fabricated of material and finish to match the ventilator.

2.7 SCREENS

Screens shall be furnished by ventilator manufacturer as part of ventilator assembly. Screen (with frames) shall be manufactured of material to match ventilators, and shall be designed to be easily removed for cleaning purposes.

2.8 FINISH

2.8.1 Galvanized Steel Finish

Galvanized steel roof ventilators shall be factory-coated with rust-resistant primer and finish coats to match metal roof panels or two-coat high-performance coating system .

2.8.2 Aluminum Finish

Aluminum roof ventilators shall be factory-finished to match metal roof finish and color or with two-coat fluoropolymer high-performance coating system .

PART 3 EXECUTION

3.1 PREPARATION

Prepare rough openings and other roof conditions in accordance with approved shop drawings and manufacturer's recommendations. Rough openings shall be field-measured and recorded on shop drawings prior to fabrication of roof ventilators. Before starting the ventilator work, protect surrounding roof surfaces from damage. Coordinate fabrication with construction schedule. Submit dimensioned drawings indicating location of each type of ventilator including details of construction, gauges of metal, and methods of operation of dampers and controls.

3.2 INSTALLATION

Coordinate roof ventilator installation with roofing work, and in accordance with approved shop drawings, manufacturer's published instructions, and chapter 8 of SMACNA 1793. The ventilator installation shall be watertight and free of vibration noise. Protect aluminum surfaces from direct contact with incompatible materials. Aluminum surfaces which will be in contact with sealant shall not be coated with a protective material. Aluminum shall not be used with copper or with water which flows over copper surfaces. Clean roof ventilators in accordance with ventilator manufacturer's recommendations.

3.3 PROTECTION

Protect exposed ventilator finish surfaces against the accumulation of paint, grime, mastic, disfigurement, discoloration and damage for duration of construction activities.

-- End of Section --

SECTION 07 81 00

SPRAY-APPLIED FIREPROOFING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATION OF THE WALL AND CEILING INDUSTRY (AWCI)

AWCI TM 12-A	(1997; 3rd Ed) Standard Practice for the Testing and Inspection of Field Applied Sprayed Fire-Resistive Materials; An Annotated Guide

ASTM INTERNATIONAL (ASTM)

ASTM E1042	(2002; R 2008e1) Acoustically Absorptive Materials Applied by Trowel or Spray
ASTM E119	(2012a) Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E605	(1993; R 2011) Thickness and Density of Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members
ASTM E736	(2000; R 2011) Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members
ASTM E759	(1992; R 2011) Effect of Deflection on Sprayed Fire-Resistive Material Applied to Structural Members
ASTM E760	(1992; R 2011) Effect of Impact on Bonding of Sprayed Fire-Resistive Material Applied to Structural Members
ASTM E761	(1992; R 2011) Compressive Strength of Sprayed Fire-Resistive Material Applied to Structural Members
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E859	(1993; R 2011) Air Erosion of Sprayed Fire-Resistive Materials (SFRMS) Applied to Structural Members

ASTM E937	(1993; R 2011) Corrosion of Steel by Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members
ASTM G21	(2013) Determining Resistance of Synthetic Polymeric Materials to Fungi

ICC EVALUATION SERVICE, INC. (ICC-ES)

ICC-ES AC23	(2004; R 2008) Acceptance Criteria for Spray-Applied and Intumescent Mastic Coating Fire-Protection Materials

UNDERWRITERS LABORATORIES (UL)

UL 263	(2011) Fire Tests of Building Construction and Materials
UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Protect all structural steel, undersides of steel floors (if required) and steel roof decks (if required) with spray-applied fireproofing to a fire resistance hour-rating as indicated below, unless otherwise indicated.

1.2.2 Fire Resistance Rating

Fire resistance ratings shall be in accordance with the fire rated assemblies listed in UL Fire Resistance. Proposed materials not listed in UL Fire Resistance shall have fire resistance ratings at least equal to the UL Fire Resistance ratings as determined by an approved independent testing laboratory, based on tests specified in UL 263 or ASTM E119. Submit reports and test records, attesting that the fireproofing material conforms to the specified requirements. Each test report shall conform to the report requirements specified by the test method. For the underside of the decking use metal lath installed prior to the fireproofing material or Rigid Board Fireproofing Material as outlined in the UL Fire Resistance Directory Volume 1. Apply fireproofing to structural steel members, with the following hourly fire resistance rating and in accordance with the following UL design or approved equivalent. Use unrestrained fire resistance ratings, unless the architect/engineer has specified that the degree of thermal restraint of the construction meets or exceeds the degree of thermal restraint of the tested assembly. Performance tests shall be in accordance with ASTM E119.

1.2.3 Evaluation Reports - ICC-ES Reports

Materials shall be evaluated in accordance with ICC-ES AC23. ICC-ES Reports shall be included as part of the Submittals below. The reports will identify the product as code compliant and having met the physical performance requirements outlined in paragraphs "Dry Density and Cohesion/Adhesion" through "Air Erosion".

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fireproofing Material; G

SD-04 Samples

Spray-Applied Fireproofing

SD-06 Test Reports

Fire Resistance Rating
Field Tests; G

SD-07 Certificates

Installer Qualifications
Surface Preparation Report; G

1.4 QUALITY ASSURANCE

1.4.1 Installer Qualifications

Engage an experienced installer that is certified, licensed, or otherwise qualified by the spray-on fireproofing manufacturer as having the necessary experience, staff, and training to install the manufacturer's products in accordance with specified requirements. Submit manufacturer's certification that each listed installer is qualified and trained to install the specified fireproofing. Show evidence that each fireproofing installer has had a minimum of 3 years experience in installing the specified type of fireproofing. Each installer of fireproofing material shall be trained, have a minimum of 3 years experience and a minimum of three installations using fireproofing of the type specified. A manufacturer's willingness to sell its products to the Contractor or installer does not infer qualification of the buyer.

1.4.2 Pre-Installation Meeting

Hold a meeting with the installer, field testing agency, the manufacturer, subcontractors (whose employees come into contact with the fireproofing), and the Contracting Officer prior to the installation of any fireproofing material to review the substrates for acceptability, method of application, applied thickness, patching, repair, inspection and testing procedures.

1.5 DELIVERY, STORAGE, AND HANDLING

Packaged material shall be delivered in the original unopened containers, marked to show the brand name, the manufacturer, and the UL markings. Fireproofing material shall be kept dry until ready to be used, and shall be stored off the ground, under cover and away from damp surfaces. Damaged or opened containers will be rejected. Material with shelf-life shall be applied prior to expiration of the shelf-life.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Temperature

Maintain substrate and ambient air temperatures above 4 degrees C (40 degrees F) during application and for 24 hours before and after application. Relative humidity shall be maintained within the limits recommended by the fireproofing manufacturer.

1.6.2 Ventilation

Provide adequate ventilation to properly dry the fireproofing after application. In enclosed areas, provide a minimum of 4 air exchanges per hour by forced air circulation.

PART 2 PRODUCTS

2.1 SPRAY-APPLIED FIREPROOFING

Provide spray-applied fireproofing material, including sealer, conforming to ASTM E1042, Class (a), Category A, either Type I or Type II, except that the dust removed shall not exceed 0.027 gram per square meter (0.0025 gram per square foot) of fireproofing material applied as specified in the project. Only products that have been evaluated at UL and bear and "investigated for exterior use" approval are allowed in waterfront areas where the fireproofing may be directly exposed to a natural body of water. Material shall be asbestos free, and shall resist fungus for a period of 28 days when tested in accordance with ASTM G21. Material shall have a flame spread of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E84. Submit one sample panel, 450 mm (18 inches) square, for each specified type of fireproofing. Also, a designated sample area of not less than 9 square m (100 square feet) shall be prepared. Sample area shall be representative of typical installation of fireproofing including metal decks, beams, columns and attachments. Equipment, materials and procedures used in the sample area shall be the same as, or representative of, that to be used in the work. The sample area shall be approved prior to proceeding with fireproofing work in any other area. The approved sample area shall be used as a reference standard for applied fireproofing material. Sample area shall remain in place and open to observation until all spray-applied fireproofing is completed and accepted, at which time it may become part of the work.

2.1.1 Dry Density and Cohesion/Adhesion

Fireproofing shall have a minimum ASTM E605 dry density and ASTM E736 cohesion/adhesion properties as follows:

2.1.1.1 Concealed Structural Components

Fireproofing for structural components concealed above the ceiling, or within a wall, chase, or furred space, shall have a minimum applied dry density of 240 kg per cubic meter (15 pounds per cubic foot) and a cohesion/adhesion strength of 9.57 kPa (200 psf).

2.1.1.2 Exposed Structural Components

Fireproofing for exposed structural components, except where otherwise specified or indicated, shall have a minimum applied dry density of 350 kg per cubic meter (22 pounds per cubic foot) and a cohesion/adhesion strength of 20.83 kPa (434 psf).

2.1.1.3 Mechanical Rooms and Storage Areas

Fireproofing for structural components located in mechanical rooms and storage areas shall have a minimum applied dry density of 640 kg per cubic meter (40 pcf) and a cohesion/adhesion strength of 350 (1,000 psf).

2.1.2 Deflection

Spray-applied fireproofing shall not crack, spall, or delaminate when backing to which it is applied is subject to downward deflection 1/120 of 3 m (10 foot) clear span, when tested in accordance with ASTM E759.

2.1.3 Bond-Impact

Spray-applied fireproofing material shall not crack, spall or delaminate when tested in accordance with ASTM E760.

2.1.4 Compressive Strength

The minimum compressive strength shall be 48 kPa (1000 psf) when tested in accordance with ASTM E761.

2.1.5 Corrosion

Spray-applied fireproofing material shall not contribute to corrosion of test panels when tested as specified in ASTM E937.

2.1.6 Air Erosion

Dust removal shall not exceed 0.25 gram per square meter (0.025 gram per square foot) when tested in accordance with ASTM E859.

2.2 SEALER

Sealer shall be the type approved by the manufacturer of the fireproofing material, shall be fungus resistant, shall have a flame spread of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E84, and shall be white or green color.

2.3 WATER

Water used for material mixing and surface preparation shall be potable.

2.4 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Thoroughly clean surfaces to be fireproofed of dirt, grease, oil, paint, primers, loose rust, rolling lubricant, mill scale or other contaminants that will interfere with the proper bonding of the sprayed fireproofing to the substrate. Test painted/primed steel substrates in accordance with ASTM E736, with specified sprayed fireproofing material, to provide the required fire-resistance rating; painted or primed steel surfaces may require a fireproofing bond test to determine if the paint formulation will impair proper adhesion. Certify the acceptability of surfaces to receive sprayed-applied fireproofing by inspection and submit a Surface Preparation Report accordingly. The statement shall list the structural members and the areas that have been inspected and certified. Overhead areas to be fireproofed shall be cleared of all obstructions interfering with the uniform application of the spray-applied fireproofing. Hardware such as support sleeves, inserts, clips, hanger attachment devices and the like shall be installed prior to the application of the fireproofing. Condition of the surfaces shall be acceptable to the manufacturer prior to application of spray-applied fireproofing. Applications listed for use on primed surfaces shall be in accordance with the manufacturer's recommendations and standards, and detailed in submittal item SD-03 Product Data.

3.2 PROTECTION

Surfaces not to receive spray-applied fireproofing shall be covered to prevent contamination by splatter, rebound and overspray. Exterior openings in areas to receive spray-applied fireproofing shall be covered prior to and during application of fireproofing with tarpaulins or other approved material. Surfaces not to receive fireproofing shall be cleaned of fireproofing and sealer.

3.3 FIREPROOFING MATERIAL

Mix fireproofing material in accordance with the manufacturer's recommendations. Submit data identifying performance characteristics of fireproofing material. Data shall include recommended application requirements and indicate thickness of fireproofing that should be applied to achieve each required fire rating.

3.4 APPLICATION

3.4.1 Sequence

Prior to application of fireproofing on each floor, the manufacturer shall inspect and approve application equipment, water supply and pressure, and the application procedures. If fireproofing is required to be applied to underside of steel roof deck and steel floor assemblies, it shall be done only after respective roof or floor construction is complete. No roof or floor traffic shall be allowed during application. Fireproofing material shall be applied prior to the installation of ductwork, piping and conduits which would interfere with uniform application of the fireproofing.

3.4.2 Application Technique

Water pressure and volume shall be maintained to manufacturer's recommendations throughout the fireproofing application. Fireproofing material shall be applied to the thickness and density established for the specified fire resistance rating, in accordance with the procedure recommended by the manufacturer, and to a uniform density and texture. Fireproofing material shall not be tamped to achieve the desired density.

3.4.3 Sealer Application

If sealer is required by the product used, it shall be applied after field testing has been conducted and after corrective measures and repairs, if required, have been completed.

3.4.4 Applied Thickness

The minimum average thickness shall be no less than 9.525 mm (0.375 inches). Thicknesses shall not be less than required to achieve designated fire resistance ratings. If the specified thickness is greater than or equal to 25 mm (1 inch), any individual measurement shall not be less than the specified thickness minus 6 mm (0.25 inches). If the specified thickness is less than 25 mm (1 inch), any individual measurement shall not be less than the specified thickness minus 25 percent.

3.5 MANUFACTURER'S SERVICES

3.5.1 General

The manufacturer, or its representative, shall be onsite prior to, periodically during, and at completion of the application, to provide the specified inspections and certifications; and to ensure that preparations are adequate and that the material is applied according to manufacturer's recommendations and the contract requirements.

3.5.2 Manufacturer's Inspection

The manufacturer shall inspect the fireproofing work after the work is completed on each floor or area, including testing, repair and clean-up, and shall certify that the work complies with the manufacturer's criteria and recommendations. Before the sprayed material is covered, and after all of the fireproofing work is completed, including repair, testing, and clean-up; and after mechanical, electrical and other work in contact with fireproofing material has been completed, the manufacturer shall re-inspect the work and certify that the entire project complies with the manufacturer's criteria and recommendations. Obtain and submit the Manufacturer's Inspection Report and certifications of approval stating that the spray-applied fireproofing in the entire project complies with the manufacturer's criteria and recommendations.

3.6 FIELD TESTS

The applied fireproofing shall be tested by an approved independent testing laboratory to be approved by the Government and paid for by the Contractor. Submit test reports documenting results of tests on the applied material in the project. Report shall include defects identified, repair procedures, and results of the retests when required. Perform the tests in approved locations: for density in accordance with ASTM E736, cohesion/adhesion in accordance with ASTM E736, and for thickness in accordance with ASTM E605. Determine densities in accordance with ASTM E605 or Appendix A, "Alternate Method for Density Determination" of AWCI TM 12-A. Take density determinations at the flat portion of deck, beam bottom flange, beam web, column, and an equivalent area from the top of the lower beam flange. Areas showing a density less than specified will be rejected. A test sample shall be located every 920 square meters (10,000 square feet) of floor area or two for each floor, whichever produces the greatest number of test areas. Any area showing less than minimum requirements shall be corrected. Proposed corrective measures, in writing, shall be approved before starting the corrective action. Corrected work shall be retested.

If the spray-applied intumescent epoxy coating system is being implemented, this testing is not required.

3.6.1 Structural Components

Each structural component type shall be tested at floor and roof decks, beams, columns, joists, and trusses. Minimum average thickness shall be as required by UL Fire Resistance. Density and cohesion/adhesion shall be as specified.

3.6.2 Repair

Additional fireproofing material may be added to provide proper thickness. Rejected areas of fireproofing shall be corrected to meet specified requirements by adding fireproofing material to provide the proper thickness, or by removing defects and respraying with new fireproofing material. Repairs shall use same type of fireproofing material as originally applied or patching materials recommended by the manufacturer. Repaired areas shall be retested and re-inspected. Fireproofing material shall be applied to voids or damaged areas by hand-trowel, or by respraying.

3.6.3 Visual Inspections

Inspections shall be made by the certified independent laboratory prior to closure of concealed areas. These inspections may be phased, but shall not occur less than 5 working days prior to the enclosure of the fireproofing. Sprayed areas shall receive a final inspection. Fireproofed surfaces shall be inspected after mechanical, electrical, and other work in contact with fireproofing material has been completed and before sprayed material is covered. Any locations missing fireproofing shall be patched in accordance with the manufacturer's requirements.

3.6.4 Patching

Patch and repair damaged fireproofing. The patching material shall be the same as that specified for that area.

3.7 CLEANUP

Surfaces not indicated to receive fireproofing shall be thoroughly cleaned of sprayed material within a 24 hour period after application.

-- End of Section --

SECTION 07 84 00

FIRESTOPPING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM E119	(2012a) Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E1399	(1997; R 2009) Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems
ASTM E1966	(2007; R 2011) Fire-Resistive Joint Systems
ASTM E2174	(2010ae1) Standard Practice for On-Site Inspection of Installed Fire Stops
ASTM E2307	(2010) Standard Test Method for Determining Fire Resistance of Perimeter Fire Barrier Systems Using Intermediate-Scale, Multi-story Test Apparatus
ASTM E2393	(2010a) Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers
ASTM E814	(2011a) Standard Test Method for Fire Tests of Through-Penetration Fire Stops
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/
FM AS 4991	(2001) Approval of Firestop Contractors

UNDERWRITERS LABORATORIES (UL)

UL 1479	(2003; Reprint Mar 2010) Fire Tests of Through-Penetration Firestops

UL 2079	(2004; Reprint Jun 2008) Tests for Fire Resistance of Building Joint Systems
UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials
UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

1.2.1 General

Furnish and install tested and listed firestopping systems, combination of materials, or devices to form an effective barrier against the spread of flame, smoke and gases, and maintain the integrity of fire resistance rated walls, partitions, floors, and ceiling-floor assemblies, including through-penetrations and construction joints and gaps.

a. Through-penetrations include the annular space around pipes, tubes, conduit, wires, cables and vents.

b. Construction joints include those used to accommodate expansion, contraction, wind, or seismic movement; firestopping material shall not interfere with the required movement of the joint.

Gaps requiring firestopping include gaps between the curtain wall and the floor slab and between the top of the fire-rated walls and the roof or floor deck above and at the intersection of shaft assemblies and adjoining fire resistance rated assemblies.

1.2.2 Sequencing

Coordinate the specified work with other trades. Apply firestopping materials, at penetrations of pipes and ducts, prior to insulating, unless insulation meets requirements specified for firestopping. Apply firestopping materials at building joints and construction gaps, prior to completion of enclosing walls or assemblies. Cast-in-place firestop devices shall be located and installed in place before concrete placement. Pipe, conduit or cable bundles shall be installed through cast-in-place device after concrete placement but before area is concealed or made inaccessible. Firestop material shall be inspected and approved prior to final completion and enclosing of any assemblies that may conceal installed firestop.

1.2.3 Submittals Requirements

a. Submit detail drawings including manufacturer's descriptive data, typical details conforming to UL Fire Resistance or other details certified by another nationally recognized testing laboratory, installation instructions or UL listing details for a firestopping assembly in lieu of fire-test data or report. For those firestop applications for which no UL tested system is available through a manufacturer, a manufacturer's engineering judgment, derived from similar UL system designs or other tests, shall be submitted for review and approval prior to installation. Submittal shall indicate the firestopping material to be provided for each type of application. When more than a total of 5 penetrations and/or construction joints are to receive firestopping, provide drawings that indicate location, "F" "T" and "L" ratings, and type of application.

b. Submit firestopping material certificate attesting to compliance with the specified requirements. For all intumescent firestop materials used in through penetration systems, manufacturer shall provide certification from UL of passing the "Aging and Environmental Exposure Testing " portion of UL 1479.

c. Submit documentation of training and experience for Installer.

d. Submit manufacturer's representative certification stating that firestopping work has been inspected and found to be applied according to the manufacturer's recommendations and the specified requirements.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G.

SD-03 Product Data

Firestopping Materials; G

SD-07 Certificates

Firestopping Material Certificate.
Installer Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Installer

Engage an experienced Installer who is:

a. FM Research approved in accordance with FM AS 4991, operating as a UL Certified Firestop Contractor, or

b. Certified, licensed, or otherwise qualified by the firestopping manufacturer as having the necessary staff, training, and a minimum of 3 years experience in the installation of manufacturer's products in accordance with specified requirements. A manufacturer's willingness to sell its firestopping products to the Contractor or to an installer engaged by the Contractor does not in itself confer installer qualifications on the buyer. The Installer shall have been trained by a direct representative of the manufacturer (not distributor or agent) in the proper selection and installation procedures. The installer shall obtain from the manufacturer written certification of training, and retain proof of certification for duration of firestop installation.

1.4.2 Manufacturer's Technical Representative

The manufacturer's technical representative shall be a direct representative of the manufacturer (not a distributor or an agent). Provide current documentation from the manufacturer that he or she is a direct representative of the manufacturer and is qualified to perform the specified inspections and certify the firestopping installation.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the original unopened packages or containers showing name of the manufacturer and the brand name. Store materials off the ground, protected from damage and exposure to elements. Remove damaged or deteriorated materials from the site.

PART 2 PRODUCTS

2.1 FIRESTOPPING MATERIALS

Provide firestopping materials, supplied from a single domestic manufacturer, consisting of commercially manufactured, asbestos-free, nontoxic, water-based, noncombustible products FM APP GUIDE approved, or UL listed, for use with applicable construction and penetrating items, complying with the following minimum requirements:

2.1.1 Fire Hazard Classification

Material shall have a flame spread of 25 or less, and a smoke developed rating of 50 or less, when tested in accordance with ASTM E84 or UL 723. Material shall be an approved firestopping material as listed in UL Fire Resistance or by a nationally recognized testing laboratory.

2.1.2 Toxicity

Material shall be nontoxic and carcinogen free to humans at all stages of application or during fire conditions and shall not contain hazardous chemicals or require harmful chemicals to clean material or equipment. Firestop material must be free from Ethylene Glycol, PCB, MEK, or other types of hazardous chemicals.

2.1.3 Fire Resistance Rating

Firestop systems shall be UL Fire Resistance listed or FM APP GUIDE approved with "F" rating at least equal to fire-rating of fire wall or floor in which penetrated openings are to be protected. Where required, firestop systems shall also have "T" rating at least equal to the fire-rated floor in which the openings are to be protected.

2.1.3.1 Through-Penetrations

Firestopping materials for through-penetrations, as described in paragraph SYSTEM DESCRIPTION, shall provide "F", "T" and "L" fire resistance ratings in accordance with ASTM E814 or UL 1479. Fire resistance ratings shall be as follows:

a. Penetrations of Fire Resistance Rated Walls and Partitions: F Rating = Rating of wall or partition being penetrated.

b. Penetrations of Fire Resistance Rated Floors, Floor-Ceiling

Assemblies and the ceiling membrane of Roof-Ceiling Assemblies: F Rating, and T Rating as indicated. Where the penetrating item is outside of a wall cavity the F rating and T rating must be equal to the fire resistance rating of the floor penetrated.

c. Penetrations of Fire and Smoke Resistance Rated Walls, Floors, Floor-Ceiling Assemblies, and the ceiling membrane of Roof-Ceiling Assemblies: F Rating and T Rating as indicated and L Rating = <5 cfm/sfWhere L rating is required.

2.1.3.2 Construction Joints and Gaps

Fire resistance ratings of construction joints, as described in paragraph SYSTEM DESCRIPTION, and gaps such as those between floor slabs or roof decks and curtain walls shall be the same as the construction in which they occur. Construction joints and gaps shall be provided with firestopping materials and systems that have been tested in accordance with ASTM E119, ASTM E1966 or UL 2079 to meet the required fire resistance rating. Curtain wall joints shall be provided with firestopping materials and systems that have been tested in accordance with ASTM E2307 to meet the required fire resistance rating. Systems installed at construction joints shall meet the cycling requirements of ASTM E1399 or UL 2079. All joints at the intersection of the top of a fire resistance rated wall and the underside of a fire-rated floor, floor ceiling, or roof ceiling assembly shall provide a minimum class II movement capability.

2.1.4 Material Performance

All firestop materials are subject to these minimum standards of performance.

a. Firestop material shall be capable of installation at temperatures of 2 to 49 degrees C (35 to 120 degrees F).

b. Material must be able to be frozen, thawed and still maintain manufacturer approval for installation.

c. Firestop material must convey a manufacturer's written warranty guaranteeing the performance of the material for the sustainable lifetime of the structure.

d. Material must maintain a shelf life of no less than two years from date of manufacturing.

e. Acceptable firestop cast-in-place devices are factory assembled intumescent lined round or oval plastic cylinders capable of protecting plastic, metallic, cable, and blank openings through the cast-in-place device equal to the fire-resistance rating of the floor.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Areas to receive firestopping shall be free of dirt, grease, oil, or loose materials which may affect the fitting or fire resistance of the firestopping system. For cast-in-place firestop devices, formwork or metal deck to receive device prior to concrete placement shall be sound and capable of supporting device. Prepare surfaces as recommended by the manufacturer.

3.2 INSTALLATION

Completely fill void spaces with firestopping material regardless of geometric configuration, subject to tolerance established by the manufacturer. Firestopping systems for filling floor voids 100 mm (4 inches) or more in any direction shall be capable of supporting the same load as the floor is designed to support or shall be protected by a permanent barrier to prevent loading or traffic in the firestopped area. Install firestopping in accordance with manufacturer's written instructions. Provide tested and listed firestop systems in the following locations, except in floor slabs on grade:

a. Penetrations of duct, conduit, tubing, cable and pipe through floors and through fire-resistance rated walls, partitions, and ceiling-floor assemblies.

b. Penetrations of vertical shafts such as pipe chases, elevator shafts, and utility chutes.

c. Gaps at the intersection of floor slabs and curtain walls, including inside of hollow curtain walls at the floor slab.

d. Gaps at perimeter of fire-resistance rated walls and partitions, such as between the top of the walls and the bottom of roof decks.

e. Construction joints in floors and fire rated walls and partitions.

f. Other locations where required to maintain fire resistance rating of the construction.

3.2.1 Insulated Pipes and Ducts

Thermal insulation shall be cut and removed where pipes or ducts pass through firestopping, unless insulation meets requirements specified for firestopping. Replace thermal insulation with a material having equal thermal insulating and firestopping characteristics.

3.2.2 Fire Dampers

Install and firestop fire dampers in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM. Firestop installed with fire damper must be tested and approved for use in fire damper system. Firestop installed with fire damper must be tested and approved for use in fire damper system.

3.2.3 Data and Communication Cabling

Cabling for data and communication applications shall be sealed with re-enterable firestopping products. Firestopping devices shall be pre-manufactured modular devices, containing built-in self-sealing intumescent inserts. Firestopping devices shall allow for cable moves, additions or changes without the need to remove or replace any firestop materials. Devices must be capable of maintaining the fire resistance rating of the penetrated membrane at 0% to 100% visual fill of penetrants; while maintaining "L" rating of <5 cfm/sf at 0% to 100% visual fill. Each device must be capable of retrofit applications and be available in square and round configurations, with single, double, triple and six-plex bracket systems provided. Firestop devices must also allow for plastic pipe, metallic pipe, and mixed multiple penetrations plastic, metallic, insulated metallic, and cable through a single device.

3.3 INSPECTION

3.3.1 General Requirements

For all projects, the firestopped areas shall not be covered or enclosed until inspection is complete and approved by the manufacturer's technical representative. The manufacturer's representative shall inspect the applications initially to ensure adequate preparations (clean surfaces suitable for application, etc.) and periodically during the work to assure that the completed work has been accomplished according to the manufacturer's written instructions and the specified requirements. Submit written reports indicating locations of and types of penetrations and types of firestopping used at each location; type shall be recorded by UL listed printed numbers.

3.3.2 Inspection Standards

Inspect all firestopping in accordance to ASTM standards for firestop inspection, and document inspection results to be submitted to GC, Architect and Owner.

a. ASTM E2393

b. ASTM E2174

-- End of Section --

SECTION 07 92 00

JOINT SEALANTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C1311	(2010) Standard Specification for Solvent Release Agents
ASTM C509	(2006; R 2011) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM C734	(2006) Low-Temperature Flexibility of Latex Sealants After Artificial Weathering
ASTM C834	(2010) Latex Sealants
ASTM C919	(2008) Use of Sealants in Acoustical Applications
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1667	(2005; R 2011) Flexible Cellular Materials - Poly (Vinyl Chloride) Foam (Closed-Cell)
ASTM D217	(2010) Cone Penetration of Lubricating Grease
ASTM D2452	(2003; R 2009) Standard Test Method for Extrudability of Oil- and Resin-Base Caulking Compounds
ASTM D2453	(2003; R 2009) Standard Test Method for Shrinkage and Tenacity of Oil- and Resin-Base Caulking Compounds
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3204	(2005) Oil Based Calking Compounds for Buildings

KS F 3215	(2000) Building Gaskets and Building Structural Gaskets-Materials in Performed Solid Vulcanizates Used for Sealing Glazing
KS F 4910	(2010) Sealants for Sealing and Glazing in Buildings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sealants

Manufacturer's descriptive data including storage requirements, shelf life, curing time, instructions for mixing and application, and primer data (if required). Provide a copy of the Material Safety Data Sheet for each solvent, primer or sealant material.

1.3 ENVIRONMENTAL CONDITIONS

Apply sealant when the ambient temperature is between 4 and 32 degrees C (40 and 90 degrees F).

1.4 DELIVERY AND STORAGE

Deliver materials to the job site in unopened manufacturers' external shipping containers, with brand names, date of manufacture, color, and material designation clearly marked thereon. Label elastomeric sealant containers to identify type, class, grade, and use. Carefully handle and store materials to prevent inclusion of foreign materials or subjection to sustained temperatures exceeding 32 degrees C (90 degrees F) or less than 4 degrees C (0 degrees F).

1.5 QUALITY ASSURANCE

1.5.1 Compatibility with Substrate

Verify that all sealants are compatible for use with joint substrates.

1.5.2 Joint Tolerance

Provide joint tolerances in accordance with manufacturer's printed instructions.

1.5.3 Mock-Up

Project personnel are responsible for installing sealants in mock-up, using materials and techniques approved for use on the project.

1.6 SPECIAL WARRANTY

Guarantee sealant joint against failure of sealant and against water penetration through each sealed joint for five years.

PART 2 PRODUCTS

2.1 SEALANTS

Provide sealant that has been tested and found suitable for the substrates to which it will be applied.

2.1.1 Interior Sealant

Provide ASTM C834, ASTM C920, Type S or M, Grade NS, Class 12.5, Use NT, or KS F 4910. Location(s) and color(s) of sealant for the following:

LOCATION	COLOR
a. Small voids between walls or partitions and adjacent lockers, casework, shelving, door frames, built-in or surface-mounted equipment and fixtures, and similar items.	Gray
b. Perimeter of frames at doors, windows, and access panels which adjoin exposed interior concrete and masonry surfaces.	Gray
c. Joints of interior masonry walls and partitions which adjoin columns, pilasters, concrete walls, and exterior walls unless otherwise detailed.	Gray
d. Joints between edge members for acoustical tile and adjoining vertical surfaces.	Gray
e. Interior locations, not otherwise indicated or specified, where small voids exist between materials specified to be painted.	Gray
f. Joints between bathtubs and ceramic tile; joints between shower receptors and ceramic tile; joints formed where nonplaner tile surfaces meet.	Gray
g. Joints formed between tile floors and tile base cove; joints between tile and dissimilar materials; joints occurring where substrates change.	Gray
h. Behind escutcheon plates at valve pipe penetrations and showerheads in showers.	Gray

2.1.2 Exterior Sealant

For joints in vertical surfaces, provide ASTM C920, Type S or M, Grade NS, Class 25, Use NT, or KS F 4910. For joints in horizontal surfaces, provide ASTM C920, Type S or M, Grade P, Class 25, Use T, or KS F 4910. Provide location(s) and color(s) of sealant as follows:

LOCATION	COLOR
a. Joints and recesses formed where frames and subsills of windows, doors, louvers, and vents adjoin masonry, concrete, or metal frames. Use sealant at both exterior and interior surfaces of exterior wall penetrations.	Gray
b. Joints between new and existing exterior masonry walls.	Gray
c. Masonry joints where shelf angles occur.	Gray
d. Joints in wash surfaces of stonework.	Gray
e. Expansion and control joints.	Gray
f. Interior face of expansion joints in exterior concrete or masonry walls where metal expansion joint covers are not required.	Gray
g. Voids where items pass through exterior walls.	Gray
h. Metal reglets, where flashing is inserted into masonry joints, and where flashing is penetrated by coping dowels.	Gray
i. Metal-to-metal joints where sealant is indicated or specified.	Gray
j. Joints between ends of gravel stops, fascias, copings, and adjacent walls.	Gray

2.1.3 Floor Joint Sealant

ASTM C920, Type S or M, Grade P, Class 25, Use T, or KS F 4910. Provide location(s) and color(s) of sealant as follows:

LOCATION	COLOR
a. Seats of metal thresholds for exterior doors.	Gray

LOCATION	COLOR
b. Control and expansion joints in floors, slabs, ceramic tile, and walkways.	Gray

2.1.4 Acoustical Sealant

Rubber or polymer-based acoustical sealant conforming to ASTM C919 must have a flame spread of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E84. Acoustical sealant must have a consistency of 250 to 310 when tested in accordance with ASTM D217, and must remain flexible and adhesive after 500 hours of accelerated weathering as specified in ASTM C734, and must be non-staining.

2.1.5 Preformed Sealant

Provide preformed sealant of polybutylene or isoprene-butylene based pressure sensitive weather resistant tape or bead sealant capable of sealing out moisture, air and dust when installed as recommended by the manufacturer. At temperatures from minus 34 to plus 71 degrees C (30 to plus 160 degrees F), the sealant must be non-bleeding and no loss of adhesion.

2.1.5.1 Foam Strip

Provide foam strip capable of sealing out moisture, air, and dust when installed and compressed as recommended by the manufacturer. Service temperature must be minus 40 to plus 135 degrees C (minus 40 to plus 275 degrees F). Furnish untreated strips with adhesive to hold them in place. Do not allow adhesive to stain or bleed into adjacent finishes. Saturate treated strips with butylene waterproofing or impregnated with asphalt.

2.2 PRIMERS

Provide a nonstaining, quick-drying type and consistency recommended by the sealant manufacturer for the particular application.

2.3 BOND BREAKERS

Provide the type and consistency recommended by the sealant manufacturer to prevent adhesion of the sealant to backing or to bottom of the joint.

2.4 BACKSTOPS

Provide glass fiber roving or neoprene, butyl, polyurethane, or polyethylene foams free from oil or other staining elements as recommended by sealant manufacturer. Provide 25 to 33 percent oversized backing for closed cell and 40 to 50 percent oversized backing for open cell material, unless otherwise indicated. Make backstop material compatible with sealant. Do not use oakum and other types of absorptive materials as backstops.

2.4.1 Rubber

Conform to ASTM D1056, Type 1, open cell, or Type 2, closed cell, Class

A, round cross section for cellular rubber sponge backing.

2.4.2 PVC

Conform to ASTM D1667, Grade VO 12, open-cell foam, round cross section for Polyvinyl chloride (PVC) backing.

2.4.3 Synthetic Rubber

Conform to ASTM C509, Option I or II, Type I or II preformed rods or tubes, or KS F 3215 for Synthetic rubber backing.

2.4.4 Neoprene

Conform to ASTM D1056, closed cell expanded neoprene cord Type 2, Class C, Grade 2C2 for Neoprene backing.

2.4.5 Butyl Rubber Based

Provide Butyl Rubber Based Sealants of single component, solvent release, color as selected, conforming to ASTM C1311.

2.4.6 Silicon Rubber Base

Provide Silicon Rubber Based Sealants of single component, solvent release, color as selected, conforming to ASTM C920, Non-sag, Class 25.

2.5 CAULKING

Conform to ASTM D2452 and ASTM D2453, or KS F 3204, for Oil- and resin-based caulking.

2.6 CLEANING SOLVENTS

Provide type(s) recommended by the sealant manufacturer.

2.7 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Clean surfaces from dirt frost, moisture, grease, oil, wax, lacquer, paint, or other foreign matter that would tend to destroy or impair adhesion. Remove oil and grease with solvent. Surfaces must be wiped dry with clean cloths. When resealing an existing joint, remove existing caulk or sealant prior to applying new sealant. For surface types not listed below, contact sealant manufacturer for specific recommendations.

3.1.1 Steel Surfaces

Remove loose mill scale by sandblasting or, if sandblasting is impractical or would damage finish work, scraping and wire brushing. Remove protective coatings by sandblasting or using a residue-free solvent.

3.1.2 Aluminum or Bronze Surfaces

Remove temporary protective coatings from surfaces that will be in contact with sealant. When masking tape is used as a protective coating, remove tape and any residual adhesive just prior to sealant application. For removing protective coatings and final cleaning, use nonstaining solvents recommended by the manufacturer of the item(s) containing aluminum or bronze surfaces.

3.1.3 Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil, or other such materials, remove materials by sandblasting or wire brushing. Remove laitance, efflorescence and loose mortar from the joint cavity.

3.1.4 Wood Surfaces

Keep wood surfaces to be in contact with sealants free of splinters and sawdust or other loose particles.

3.2 SEALANT PREPARATION

Do not add liquids, solvents, or powders to the sealant. Mix multi-component elastomeric sealants in accordance with manufacturer's instructions.

3.3 APPLICATION

3.3.1 Joint Width-To-Depth Ratios

a. Acceptable Ratios:

JOINT WIDTH	JOINT DEPTH	
	Minimum	Maximum
For metal, glass, or other nonporous surfaces:		
6 mm (minimum)	6 mm	6 mm
over 6 mm	1/2 of width	Equal to width
For wood, concrete, masonry, or stone:		
6 mm (minimum)	6 mm	6 mm
over 6 mm to 13 mm	6 mm	Equal to width
over 13 mm to 50 mm	50 mm	16 mm
Over 50 mm	As recommended by sealant manufacturer	

JOINT WIDTH	JOINT DEPTH	
	Minimum	Maximum
For metal, glass, or other nonporous surfaces:		
1/4 inch (minimum)	1/4 inch	1/4 inch
over 1/4 inch	1/2 of width	Equal to width
For wood, concrete, masonry, stone:		
1/4 inch (minimum)	1/4 inch	1/4 inch
over 1/4 inch to 1/2 inch	1/4 inch	Equal to width
over 1/2 inch to 2 inch	1/2 inch	5/8 inch
Over 2 inch	As recommended by sealant manufacturer	

b. Unacceptable Ratios: Where joints of acceptable width-to-depth ratios have not been provided, clean out joints to acceptable depths and grind or cut to acceptable widths without damage to the adjoining work. Grinding is not required on metal surfaces.

3.3.2 Masking Tape

Place masking tape on the finish surface on one or both sides of a joint cavity to protect adjacent finish surfaces from primer or sealant smears. Remove masking tape within 10 minutes after joint has been filled and tooled.

3.3.3 Backstops

Install backstops dry and free of tears or holes. Tightly pack the back or bottom of joint cavities with backstop material to provide a joint of the depth specified. Install backstops in the following locations:

a. Where indicated.

b. Where backstop is not indicated but joint cavities exceed the acceptable maximum depths specified in paragraph entitled, "Joint Width-to-Depth Ratios".

3.3.4 Primer

Immediately prior to application of the sealant, clean out loose particles from joints. Where recommended by sealant manufacturer, apply primer to joints in concrete masonry units, wood, and other porous surfaces in accordance with sealant manufacturer's instructions. Do not apply primer to exposed finish surfaces.

3.3.5 Bond Breaker

Provide bond breakers to the back or bottom of joint cavities, as recommended by the sealant manufacturer for each type of joint and sealant used, to prevent sealant from adhering to these surfaces. Carefully apply the bond breaker to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond breaker.

3.3.6 Sealants

Provide a sealant compatible with the material(s) to which it is applied. Do not use a sealant that has exceeded shelf life or has jelled and cannot be discharged in a continuous flow from the gun. Apply the sealant in accordance with the manufacturer's printed instructions with a gun having a nozzle that fits the joint width. Force sealant into joints to fill the joints solidly without air pockets. Tool sealant after application to ensure adhesion. Make sealant uniformly smooth and free of wrinkles. Upon completion of sealant application, roughen partially filled or unfilled joints, apply sealant, and tool smooth as specified. Apply sealer over the sealant when and as specified by the sealant manufacturer.

3.4 PROTECTION AND CLEANING

3.4.1 Protection

Protect areas adjacent to joints from sealant smears. Masking tape may be used for this purpose if removed 5 to 10 minutes after the joint is filled.

3.4.2 Final Cleaning

Upon completion of sealant application, remove remaining smears and stains and leave the work in a clean and neat condition.

a. Masonry and Other Porous Surfaces: Immediately scrape off fresh sealant that has been smeared on masonry and rub clean with a solvent as recommended by the sealant manufacturer. Allow excess sealant to cure for 24 hour then remove by wire brushing or sanding.

b. Metal and Other Non-Porous Surfaces: Remove excess sealant with a solvent-moistened cloth.

-- End of Section --

SECTION 08 11 13

STEEL DOORS AND FRAMES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A879/A879M	(2006) Standard Specification for Steel Sheet, zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM C578	(2011be1) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C591	(2012a) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C612	(2014) Mineral Fiber Block and Board Thermal Insulation
ASTM D2863	(2010) Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM E1300	(2009a) Determining Load Resistance of Glass in Buildings
ASTM F2248	(2009) Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.115	(2006) Hardware Preparation in Steel Doors and Steel Frames

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 8304	(2003) Electroplated Coatings of Zinc

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM HMMA HMM	(1999; R2000) Hollow Metal Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 105	(2010) Standard for Installation of Smoke Door Assemblies and Other Opening Protectives
NFPA 252	(2008) Standard Methods of Fire Tests of Door Assemblies
NFPA 80	(2013) Standard for Fire Doors and Other Opening Protectives

STEEL DOOR INSTITUTE (SDI/DOOR)

SDI/DOOR 111	(2009) Recommended Selection and Usage Guide for Standard Steel Doors, Frames and Accessories
SDI/DOOR 113	(2001; R2006) Standard Practice for Determining the Steady State Thermal Transmittance of Steel Door and Frame Assemblies
SDI/DOOR A250.11	(2001) Recommended Erection Instructions for Steel Frames
SDI/DOOR A250.4	(2001) Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcing
SDI/DOOR A250.6	(2003; R2009) Recommended Practice for Hardware Reinforcing on Standard Steel Doors and Frames
SDI/DOOR A250.8	(2003; R2008) Recommended Specifications for Standard Steel Doors and Frames

UNDERWRITERS LABORATORIES (UL)

UL 10C	(2009) Standard for Positive Pressure Fire Tests of Door Assemblies

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Door Drawings; G
Door Schedule; G

SD-03 Product Data

Doors
Frames
Accessories

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver doors, frames, and accessories undamaged and with protective wrappings or packaging. Strap knock-down frames in bundles. Provide temporary steel spreaders securely fastened to the bottom of each welded frame. Store doors and frames on platforms under cover in clean, dry, ventilated, and accessible locations, with 6 mm (1/4 inch) airspace between doors. Remove damp or wet packaging immediately and wipe affected surfaces dry. Replace damaged materials with new.

1.4 Shop Drawings

Submit for approval door drawings showing elevations, construction details, metal gages, hardware provisions, method of glazing, and installation details, including frames and accessories. Include data and details on door construction, panel (internal) reinforcement, insulation, and door edge construction.

Submit door schedule showing door and frame locations.

PART 2 PRODUCTS

2.1 STANDARD STEEL DOORS

SDI/DOOR A250.8, except as specified otherwise. Prepare doors to receive door hardware as specified in Section 08 71 00. Undercut where indicated. Exterior doors shall have top edge closed flush and sealed to prevent water intrusion. Doors shall be 44.5 mm (1-3/4 inch) thick, unless otherwise indicated. If indicated on contract drawings provide exterior glazing in accordance with ASTM F2248 and ASTM E1300.

2.1.1 Classification - Level, Performance, Model

2.1.1.1 Standard Duty Doors

SDI/DOOR A250.8, Level 1, physical performance Level C, Model 1 or 2, of size(s) and design(s) indicated and core construction as required by the manufacturer.

2.1.1.2 Heavy Duty Doors

SDI/DOOR A250.8, Level 2, physical performance Level B, Model 1 or 2, with core construction as required by the manufacturer for interior doors and for exterior doors, of size(s) and design(s) indicated. Where vertical stiffener cores are required, the space between the stiffeners shall be filled with mineral board insulation.

2.1.1.3 Extra Heavy Duty Doors

SDI/DOOR A250.8, Level 3, physical performance Level A, Model 1, 2 or 3 with core construction as required by the manufacturer for interior doors and for indicated exterior doors, of size(s) and design(s) indicated. Where vertical stiffener cores are required, the space between the stiffeners shall be filled with mineral board insulation.

2.1.1.4 Maximum Duty Doors

SDI/DOOR A250.8, Level 4, physical performance Level A, Model 1 or 2 with core construction as required by the manufacturer for interior doors and for indicated exterior doors, of size(s) and design(s) indicated.Where vertical stiffener cores are required, the space between the stiffeners shall be filled with mineral board insulation.

2.2 CUSTOM HOLLOW METAL DOORS

Provide custom hollow metal doors where nonstandard steel doors are indicated. At the Contractor's option, custom hollow metal doors may be provided in lieu of standard steel doors. Door size(s), design(s), materials, construction, gages, and finish shall be as specified for standard steel doors and shall comply with the requirement of NAAMM HMMA HMM. Fill all spaces in doors with insulation. Close top and bottom edges with steel channels not lighter than 1.5 mm thick (16 gage).Close tops of exterior doors flush with an additional channel and seal to prevent water intrusion. Prepare doors to receive hardware specified in Section 08 71 00 DOOR HARDWARE. Undercut doors where indicated. Doors shall be 44.5 mm (1-3/4 inch) thick, unless otherwise indicated.

2.3 INSULATED STEEL DOOR SYSTEMS

Insulated steel doors shall have a core of polyurethane foam and an R factor of 10.0 or more (based on a k value of 0.16); face sheets, edges, and frames of galvanized steel not lighter than 0.7 mm thick (23 gage), 1.5 mm thick (16 gage), and 1.5 mm (16 gage) respectively; magnetic weather-stripping; non-removable pin hinges; thermal-break aluminum threshold; and vinyl door bottom. Doors and frames shall receive phosphate treatment, rust-inhibitive primer, and baked acrylic enamel finish. Doors shall have been tested in accordance with SDI/DOOR A250.4 and shall have met the requirements for Level C. Prepare doors to receive specified hardware. Doors shall be 44.5 mm (1-3/4 inch) thick. Provide insulated steel doors and frames where indicated.

2.4 SOUND RATED STEEL DOORS

Doors shall have a Sound Transmission Class (STC) as indicated on the drawings.

2.5 ACCESSORIES

2.5.1 Shelves for Dutch Doors

SDI/DOOR 111. Fabricate shelves of steel not lighter than 1.5 mm thick (16 gage). Brackets shall be stock type fabricated of the same metal used to fabricate shelves.

2.5.2 Louvers

2.5.2.1 Interior Louvers

SDI/DOOR 111, Louvers shall be stationary sightproof and lightproof type where scheduled. Louvers for lightproof doors shall not transmit light. Detachable moldings on room or non security side of door; on security side of door, moldings to be integral part of louver. Form louver frames of 0.9 mm thick (20 gage) steel and louver blades of a minimum 0.6 mm (24 gage).

2.5.2.2 Exterior Louvers

Louvers shall be inverted "Y", "V" or "Z" type with minimum of 30 percent net-free opening. Weld or tenon louver blades to continuous channel frame and weld assembly to door to form watertight assembly. Form louvers of hot-dip galvanized steel of same gage as door facings. Louvers shall have steel-framed insect screens secured to room side and readily removable. Provide aluminum wire cloth, 7 by 7 per 10 mm or 7 by 6 per 10 mm (18 by 18 or 18 by 16 inch) mesh, for insect screens. Net-free louver area to be before screening.

2.5.3 Astragals

For pairs of exterior steel doors which will not have aluminum astragals or removable mullions, as specified in Section 08 71 00 DOOR HARDWARE, provide overlapping steel astragals with the doors. For interior pairs of fire rated and smoke control doors, provide stainless steel astragals complying with NFPA 80 for fire rated assemblies and NFPA 105 for smoke control assemblies.

2.5.4 Moldings

Provide moldings around glass of interior and exterior doors and louvers of interior doors. Provide non-removable moldings on outside of exterior doors and on corridor side of interior doors. Other moldings may be stationary or removable. Secure inside moldings to stationary moldings, or provide snap-on moldings. Muntins shall interlock at intersections and shall be fitted and welded to stationary moldings.

2.6 INSULATION CORES

Insulated cores shall be of type specified, and provide an apparent U-factor of .48 in accordance with SDI/DOOR 113 and shall conform to:

a. Rigid Cellular Polyisocyanurate Foam: ASTM C591, Type I or II, foamed-in-place or in board form, with oxygen index of not less than 22 percent when tested in accordance with ASTM D2863; or

b. Rigid Polystyrene Foam Board: ASTM C578, Type I or II; or

c. Mineral board: ASTM C612, Type I.

2.7 STANDARD STEEL FRAMES

SDI/DOOR A250.8, Level 1, unless otherwise indicated. Form frames to sizes and shapes indicated, with welded corners or knock-down field-assembled corners. Provide steel frames for doors, transoms, sidelights, mullions, cased openings, and interior glazed panels, unless otherwise indicated.

2.7.1 Welded Frames

Continuously weld frame faces at corner joints. Mechanically interlock or continuously weld stops and rabbets. Grind welds smooth.

Weld frames in accordance with the recommended practice of the Structural Welding Code Sections 1 through 6, AWS D1.1/D1.1M and in accordance with the practice specified by the producer of the metal being welded.

2.7.2 Knock-Down Frames

Design corners for simple field assembly by concealed tenons, splice plates, or interlocking joints that produce square, rigid corners and a tight fit and maintain the alignment of adjoining members. Provide locknuts for bolted connections.

2.7.3 Mullions and Transom Bars

Mullions and transom bars shall be closed or tubular construction and be a member with heads and jambs butt-welded thereto or knock-down for field assembly. Bottom of door mullions shall have adjustable floor anchors and spreader connections.

2.7.4 Stops and Beads

Form stops and beads from 0.9 mm thick (20 gage) steel. Provide for glazed and other openings in standard steel frames. Secure beads to frames with oval-head, countersunk Phillips self-tapping sheet metal screws or concealed clips and fasteners. Space fasteners approximately 300 to 400 mm (12 to 16 inch) on center. Miter molded shapes at corners. Butt or miter square or rectangular beads at corners.

2.7.5 Terminated Stops

Where indicated, terminate interior door frame stops 150 mm (6 inch) above floor. Do not terminate stops of frames for lightproof or soundproof doors.

2.7.6 Cased Openings

Fabricate frames for cased openings of same material, gage, and assembly as specified for metal door frames, except omit door stops and preparation for hardware.

2.7.7 Anchors

Provide anchors to secure the frame to adjoining construction. Provide steel anchors, zinc-coated or painted with rust-inhibitive paint, not lighter than 1.2 mm thick (18 gage).

2.7.7.1 Wall Anchors

Provide at least three anchors for each jamb. For frames which are more than 2285 mm (7.5 feet) in height, provide one additional anchor for each jamb for each additional 760 mm (2.5 feet) or fraction thereof.

a. Masonry: Provide anchors of corrugated or perforated steel straps or 5 mm (3/16 inch) diameter steel wire, adjustable or T-shaped;

b. Stud partitions: Weld or otherwise securely fasten anchors to backs of frames. Unless otherwise indicated, design anchors to be fastened to closed steel studs with sheet metal screws, and to open steel studs by wiring or welding;

c. Completed openings: Secure frames to previously placed concrete or masonry with expansion bolts in accordance with SDI/DOOR 111; and

d. Solid plaster partitions: Secure anchors solidly to back of frames and tie into the lath. Provide adjustable top strut anchors on each side of frame for fastening to structural members or ceiling construction above. Size and type of strut anchors shall be as recommended by the frame manufacturer.

2.7.7.2 Floor Anchors

Provide floor anchors drilled for 10 mm (3/8 inch) anchor bolts at bottom of each jamb member. Where floor fill occurs, terminate bottom of frames at the indicated finished floor levels and support by adjustable extension clips resting on and anchored to the structural slabs.

2.8 FIRE AND SMOKE DOORS AND FRAMES

NFPA 80 and NFPA 105 and this specification. The requirements of NFPA 80 and NFPA 105 shall take precedence over details indicated or specified.

2.8.1 Labels

Fire doors and frames shall bear the label of Underwriters Laboratories (UL), Factory Mutual Engineering and Research (FM), or Warnock Hersey International (WHI) attesting to the rating required. Testing shall be in accordance with NFPA 252 or UL 10C. Labels shall be metal with raised letters, and shall bear the name or file number of the door and frame manufacturer. Labels shall be permanently affixed at the factory to frames and to the hinge edge of the door. Door labels shall not be painted.

2.8.2 Oversized Doors

For fire doors and frames which exceed the size for which testing and labeling are available, furnish certificates stating that the doors and frames are identical in design, materials, and construction to a door which has been tested and meets the requirements for the class indicated.

2.8.3 Astragal on Fire and Smoke Doors

On pairs of labeled fire doors, conform to NFPA 80 and UL requirements. On smoke control doors, conform to NFPA 105.

2.9 WEATHERSTRIPPING

As specified in Section 08 71 00 DOOR HARDWARE.

2.10 HARDWARE PREPARATION

Provide minimum hardware reinforcing gages as specified in SDI/DOOR A250.6. Drill and tap doors and frames to receive finish hardware. Prepare doors and frames for hardware in accordance with the applicable requirements of SDI/DOOR A250.8 and SDI/DOOR A250.6. For additional requirements refer to ANSI/BHMA A156.115. Drill and tap for surface-applied hardware at the project site. Build additional reinforcing for surface-applied hardware into the door at the factory. Locate hardware in accordance with the requirements of SDI/DOOR A250.8, as applicable. Punch door frames, with the exception of frames that will have weather-stripping, lightproof or soundproof gasketing, to receive a minimum of two rubber or vinyl door silencers on lock side of single doors and one silencer for each leaf at heads of double doors. Set lock strikes out to provide clearance for silencers.

2.11 FINISHES

2.11.1 Factory-Primed Finish

All surfaces of doors and frames shall be thoroughly cleaned, chemically treated and factory primed with a rust inhibiting coating as specified in SDI/DOOR A250.8.

2.11.2 Hot-Dip Zinc-Coated and Factory-Primed Finish

Fabricate doors and frames from hot dipped zinc coated steel, alloyed type, that complies with ASTM A924/A924M and ASTM A653/A653M, or KS D 3506. The coating weight shall meet or exceed the minimum requirements for coatings having 122 grams per square meter (0.4 ounces per square foot), total both sides, i.e., ZF120 (A40). Repair damaged zinc-coated surfaces by the application of zinc dust paint. Thoroughly clean and chemically treat to insure maximum paint adhesion. Factory prime as specified in SDI/DOOR A250.8.

2.11.3 Electrolytic Zinc-Coated Anchors and Accessories

Provide electrolytically deposited zinc-coated steel in accordance with ASTM A879/A879M, Commercial Quality, Coating Class A, or KS D 8304. Phosphate treat and factory prime zinc-coated surfaces as specified in SDI/DOOR A250.8.

2.12 FABRICATION AND WORKMANSHIP

Finished doors and frames shall be strong and rigid, neat in appearance, and free from defects, waves, scratches, cuts, dents, ridges, holes, warp, and buckle. Molded members shall be clean cut, straight, and true, with joints coped or mitered, well formed, and in true alignment. Dress exposed welded and soldered joints smooth. Design door frame sections for use with the wall construction indicated. Corner joints shall be well formed and in true alignment. Conceal fastenings where practicable.

2.12.1 Grouted Frames

For frames to be installed in exterior walls and to be filled with mortar or grout, fill the stops with strips of rigid insulation to keep the grout out of the stops and to facilitate installation of stop-applied head and jamb seals.

2.13 PROVISIONS FOR GLAZING

Materials are specified in Section 08 81 00, GLAZING.

2.14 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Frames

Set frames in accordance with SDI/DOOR A250.11. Plumb, align, and brace securely until permanent anchors are set. Anchor bottoms of frames with expansion bolts or powder-actuated fasteners. Build in or secure wall anchors to adjoining construction. Where frames require ceiling struts or overhead bracing, anchor frames to the struts or bracing. Backfill frames with mortar. Coat inside of frames with corrosion-inhibiting bituminous material. For frames in exterior walls, ensure that stops are filled with rigid insulation before grout is placed.

3.1.2 Doors

Hang doors in accordance with clearances specified in SDI/DOOR A250.8. After erection and glazing, clean and adjust hardware.

3.1.3 Fire and Smoke Doors and Frames

Install fire doors and frames, including hardware, in accordance with NFPA 80. Install fire rated smoke doors and frames in accordance with NFPA 80 and NFPA 105.

3.2 PROTECTION

Protect doors and frames from damage. Repair damaged doors and frames prior to completion and acceptance of the project or replace with new, as directed. Wire brush rusted frames until rust is removed. Clean thoroughly. Apply an all-over coat of rust-inhibitive paint of the same type used for shop coat.

3.3 CLEANING

Upon completion, clean exposed surfaces of doors and frames thoroughly. Remove mastic smears and other unsightly marks.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Door thickness	1-3/4 inch	44.5 mm
Steel channels	16 gage	1.5 mm
Steel Sheet	23 gage	0.7 mm
	16 gage	1.5 mm
	20 gage	0.9 mm
	18 gage	1.2 mm
Anchor bolts	3/8 inch	10 mm

-- End of Section --

SECTION 08 11 16

ALUMINUM DOORS AND FRAMES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2604	(2005) Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM E1300	(2009a) Determining Load Resistance of Glass in Buildings
ASTM E283	(2004) Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E331	(2000; R 2009) Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
ASTM F1642	(2004; R 2010) Standard Test Method for

	Glazing and Glazing Systems Subject to Airblast Loadings
ASTM F2248	(2009) Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 6701	(2012) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6759	(2011) Aluminum and Aluminum Alloy Extruded Shapes
KS D 8303	(2009) Combined coatings of anodic oxide and organic coatings on aluminum and aluminum alloys

1.2 PERFORMANCE REQUIREMENTS

1.2.1 Structural

Exterior doors, frames and hardware shall be designed to resist equivalent static design loads in accordance with ASTM F1642. Frame deflections shall not exceed L/160 of the unsupported member lengths. Equivalent static design loads for connections of window or door frame to the surrounding walls or hardware and associated connections, and glazing stop connections shall be in accordance with ASTM F2248 and ASTM E1300. Design supporting elements and their connections based on their ultimate capacities. Use frames that provide an equivalent level of performance. Shapes and thicknesses of framing members shall be sufficient to withstand the design wind load indicated with a deflection of not more than 1/175 times the length of the member and a safety factor of not less than 1.65. Provide glazing beads, moldings, and trim of not less than 1.25 mm (0.050 inch) nominal thickness.

1.2.2 Air Infiltration

When tested in accordance with ASTM E283, air infiltration shall not exceed 2.63 by 10-5 cms per square meter (0.06 cubic feet per minute per square foot)of fixed area at a test pressure of 0.30 kPa (6.24 pounds per square foot) (80 kilometers (50 mile) per hour wind).

1.2.3 Water Penetration

When tested in accordance with ASTM E331, there shall be no water penetration at a pressure of 0.38 kPa (8 pounds per square foot) of fixed area.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Door and Frame Drawings; G

SD-03 Product Data

Doors and Frames

SD-10 Operation and Maintenance Data

Maintenance of Doors and Frames

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for damage. Unload and store with minimum handling. Provide storage space in dry location with adequate ventilation, free from dust or water, and easily accessible for inspection and handling. Stack materials on non-absorptive strips or wood platforms. Do not cover doors and frames with tarps, polyethylene film, or similar coverings. Protect finished surfaces during shipping and handling using manufacturer's standard method, except that no coatings or lacquers shall be applied to surfaces to which calking and glazing compounds must adhere.

1.5 QUALITY CONTROL

1.5.1 Shop Drawing Requirements

Submit door and frame drawings indicating elevations and sizes of doors and frames, full-size sections, thickness and gages of metal, fastenings, proposed method of anchoring, size and spacing of anchors, details of construction, method of glazing, details of operating hardware, mullion details, method and materials for weather-stripping, material and method of attaching subframes, trim, installation details, and other related items.

1.5.2 Sample Requirements

1.5.2.1 Finish Sample Requirements

Submit color chart of standard factory-finish color coatings.

PART 2 PRODUCTS

2.1 DOORS AND FRAMES

Swing-type aluminum doors and frames of size, design, and location indicated. Provide doors complete with frames, framing members, subframes, transoms, adjoining sidelights, adjoining window wall, trim, and accessories.

2.2 MATERIALS

2.2.1 Anchors

Stainless steel or steel with hot-dipped galvanized finish.

2.2.2 Weather-stripping

Continuous wool pile, silicone treated, or type recommended by door manufacturer.

2.2.3 Aluminum Alloy for Doors and Frames

ASTM B221M (ASTM B221), alloy 6063-T5 for extrusions or KS D 6759. ASTM B209M (ASTM B209), alloy and temper best suited for aluminum sheets and strips, or KS D 6701.

2.2.4 Fasteners

Hard aluminum or stainless steel.

2.2.5 Structural Steel

ASTM A36/A36M or KS D 3515.

2.2.6 Aluminum Paint

Aluminum door manufacturer's standard aluminum paint.

2.3 FABRICATION

2.3.1 Aluminum Frames

Extruded aluminum shapes with contours approximately as indicated. Provide removable glass stops and glazing beads for frames accommodating fixed glass. Use countersunk stainless steel Phillips screws for exposed fastenings, and space not more than 300 mm (12 inches) on center. Mill joints in frame members to a hairline fit, reinforce, and secure mechanically.

2.3.2 Aluminum Doors

Of type, size, and design indicated and not less than 45 mm (1-3/4 inch) thick. Minimum wall thickness, 3 mm (0.125 inch), except beads and trim, 1.25 mm (0.050 inch). Door sizes shown are nominal and shall include standard clearances as follows: 2.5 mm (0.093 inch) at hinge and lock stiles, 3 mm (0.125 inch) between meeting stiles, 3 mm (0.125 inch) at top rails, 5 mm (0.187 inch) between bottom and threshold, and 17 mm (0.687 inch) between bottom and floor. Bevel single-acting doors 2 or 3 mm (0.063 or 0.125 inch) at lock, hinge, and meeting stile edges. Double-acting doors shall have rounded edges at hinge stile, lock stile, and meeting stile edges.

2.3.2.1 Full Glazed Stile and Rail Doors

Doors shall have narrow, medium, or wide stiles and rails as indicated. Fabricate from extruded aluminum hollow seamless tubes or from a combination of open-shaped members interlocked or welded together. Fasten top and bottom rail together by means of welding or by 10 or 13 mm (3/8 or 1/2 inch) diameter cadmium-plated tensioned steel tie rods. Provide an adjustable mechanism of jack screws or other methods in the top rail to allow for minor clearance adjustments after installation.

2.3.2.2 Flush Doors

Use facing sheets with a vertical ribbed, an embossed, or a plain smooth surface. Use one of the following constructions:

a. A phenolic resin-impregnated kraft paper honeycomb core, surrounded at edges and around glass and louvered areas with extruded aluminum shapes. The impregnation of core shall have a minimum of 18 percent resin content. Provide sheet aluminum door facings, not less than 0.8 mm (0.032 inch) thick laminated to a 2.5 mm (0.10 inch) thick tempered hardboard backing, and bond the backing to the honeycomb core. Bond facing sheets to core under heat and pressure with a thermosetting adhesive, and mechanically lock to the extruded edge members.

b. A phenolic resin-impregnated kraft paper honeycomb core. Use aluminum facing sheets not less than 1.25 mm (0.050 inch) thick and form into two pans which will eliminate seams on the faces. Bond honeycomb core to the face sheets using an epoxy resin or contact cement-type adhesive.

c. A solid fibrous core, surrounded at edges and around glass and louvered areas and cross-braced at intermediate points with extruded aluminum shapes. Use aluminum facing sheets of not less than 1.25 mm (0.050 inch) thickness. Bond facing sheets to core under heat and pressure with a thermosetting adhesive, and mechanically lock to the extruded edge members.

d. Form from extruded tubular stiles and rails mitered at corners, reinforce, and continuously weld at miters. Facing sheets shall consist of 0.8 mm (0.032 inch) thick sheet aluminum internally reinforced with aluminum channels or Z-bars placed horizontally not more than 400 mm (16 inch) apart and extending full width of panel. Fit spaces between reinforcing with sound-deadening insulation. Facing sheets shall finish flush with faces of stiles and rails and be welded to reinforcing bars or channels and to stiles and rails.

e. Form from an internal grid system composed of extruded aluminum tubular sections. Provide extruded aluminum tubular sections at both sides, and at perimeters of louver and glass cutouts. Provide three extruded aluminum tubular sections at top and bottom of door. Wall thickness of tubular sections shall be not less than 2.25 mm (0.09 inch) except that lock rail shall be not less than 3 mm(0.125 inch) thick, hinge lock rail shall be not less than 3 mm (0.125 inch) thick, and hinge rail edge shall be not less than 5 mm (0.19 inch) thick. Fill spaces in door with mineral insulation. Facing sheets shall be of aluminum not less than 2.25 mm (0.09 inch) thick.

f. Form from extruded aluminum members at top and bottom, both sides, and at perimeters of louver and glass cutouts. Wall sections of extruded aluminum members shall be not less than 2.25 mm (0.09 inch) thick and be properly reinforced for application of hardware. Framing members shall be covered on both sides with aluminum facing sheets not less than 2 mm (0.064 inch) thick. Fill door with foamed-in urethane with a 48 kg per cubic meter (3 pound) density.

2.3.3 Welding and Fastening

Where possible, locate welds on unexposed surfaces. Dress welds on exposed surfaces smoothly. Select welding rods, filler wire, and flux to produce a uniform texture and color in finished work. Remove flux and spatter from surfaces immediately after welding. Exposed screws or bolts will be permitted only in inconspicuous locations, and shall have countersunk heads. Weld concealed reinforcements for hardware in place.

2.3.4 Weather-stripping

Provide on stiles and rails of exterior doors. Fit into slots which are integral with doors or frames. Weather-stripping shall be replaceable without special tools, and adjustable at meeting rails of pairs of doors. Installation shall allow doors to swing freely and close positively. Air leakage of a single leaf weatherstripped door shall not exceed 2.19 by 10-5 cubic meter per second of air per square meter (0.5 cubic feet per minute of air per square foot) of door area when tested in accordance with ASTM E283.

2.3.5 Anchors

On the backs of subframes, provide anchors of the sizes and shapes indicated for securing subframes to adjacent construction. Anchor transom bars at ends and mullions at head and sill. Where indicated, reinforce vertical mullions with structural steel members of sufficient length to extend up to the overhead structural slab or framing and secure thereto. Reinforce and anchor freestanding door frames to floor construction as indicated on approved shop drawings and in accordance with manufacturer's recommendation. Place anchors as indicated or near top and bottom of each jamb and at intermediate points not more than 635 mm (25 inch) apart.

2.3.6 Provisions for Hardware

Coordinate with Section 08 71 00 DOOR HARDWARE. Deliver hardware templates and hardware (except field-applied hardware) to the door manufacturer for use in fabrication of aluminum doors and frames. Cut, reinforce, drill, and tap doors and frames at the factory to receive template hardware. Provide doors to receive surface-applied hardware, except push plates, kick plates, and mop plates, with reinforcing only; drill and tap in the field. Provide hardware reinforcements of stainless steel or steel with hot-dipped galvanized finish, and secure with stainless steel screws. Provide reinforcement in core of flush doors as required to receive locks, door closers, and other hardware.

2.3.7 Provisions for Glazing

Provide extruded aluminum snap-in glazing beads on interior side of doors. Provide extruded aluminum, theft-proof, snap-in glazing beads or fixed glazing beads on exterior or security side of doors. Glazing beads shall have vinyl insert glazing gaskets. Design glazing beads to receive glass of thickness indicated or specified.

2.3.8 Finishes

Provide exposed aluminum surfaces with factory finish of anodic coating or organic coating.

2.3.8.1 Anodic Coating

Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF45 or KS D 8303. Finish shall be clear (natural), designation AA-M10-C22-A31, Architectural Class II 0.01 to 0.0175 mm (0.4 mil to 0.7

mil), unless otherwise indicated on contract drawings. Color shall be as indicated.

2.3.8.2 Organic Coating

Clean and prime exposed aluminum surfaces. Provide a high-performance finish in accordance with AAMA 2604 with total dry film thickness of not less than 0.03 mm (1.2 mils). The finish color shall be as indicated.

2.4 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Plumb, square, level, and align frames and framing members to receive doors, transoms, adjoining sidelights, and, adjoining window walls. Anchor frames to adjacent construction as indicated and in accordance with manufacturer's printed instructions. Anchor bottom of each frame to rough floor construction with 2.4 mm (3/32 inch) thick stainless steel angle clips secured to back of each jamb and to floor construction; use stainless steel bolts and expansion rivets for fastening clip anchors. Hang doors to produce clearances specified in paragraph entitled "Aluminum Doors," of this section. After erection and glazing, adjust doors and hardware to operate properly.

3.2 PROTECTION FROM DISSIMILAR MATERIALS

3.2.1 Dissimilar Metals

Where aluminum surfaces come in contact with metals other than stainless steel, zinc, or small areas of white bronze, protect from direct contact to dissimilar metals.

3.2.1.1 Protection

Provide one of the following systems to protect surfaces in contact with dissimilar metals:

a. Paint the dissimilar metal with one coat of heavy-bodied bituminous paint.

b. Apply a good quality elastomeric sealant between the aluminum and the dissimilar metal.

c. Paint the dissimilar metal with one coat of primer and one coat of aluminum paint.

d. Use a non-absorptive tape or gasket in permanently dry locations.

3.2.2 Drainage from Dissimilar Metals

In locations where drainage from dissimilar metals has direct contact with aluminum, provide protective paint to prevent aluminum discoloration.

3.2.3 Masonry and Concrete

Provide aluminum surfaces in contact with mortar, concrete, or other masonry materials with one coat of heavy-bodied bituminous paint.

3.2.4 Wood or Other Absorptive Materials

Provide aluminum surfaces in contact with absorptive materials subject to frequent moisture, and aluminum surfaces in contact with treated wood, with two coats of aluminum paint or one coat of heavy-bodied bituminous paint. In lieu of painting the aluminum, the Contractor shall have the option of painting the wood or other absorptive surface with two coats of aluminum paint and sealing the joints with elastomeric sealant.

3.3 CLEANING

Upon completion of installation, clean door and frame surfaces in accordance with door manufacturer's written recommended procedure. Do not use abrasive, caustic, or acid cleaning agents.

Submit manufacturer's instructions for installation, adjustment, cleaning, and maintenance of doors and frames.

3.4 PROTECTION

Protect doors and frames from damage and from contamination by other materials such as cement mortar. Prior to completion and acceptance of the work, restore damaged doors and frames to original condition, or replace with new ones.

-- End of Section --

SECTION 08 14 00

WOOD DOORS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ARCHITECTURAL WOODWORK INSTITUTE (AWI)

AWI AWS	(2009) Architectural Woodwork Standards

ASTM INTERNATIONAL (ASTM)

ASTM E2226	(2011) Standard Practice for Application of Hose Stream
ASTM E283	(2004) Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E90	(2009) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3109	(2009) Doorsets

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA LD 3	(2005) Standard for High-Pressure Decorative Laminates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 105	(2010) Standard for Installation of Smoke Door Assemblies and Other Opening Protectives
NFPA 252	(2008) Standard Methods of Fire Tests of Door Assemblies
NFPA 80	(2013) Standard for Fire Doors and Other Opening Protectives

UNDERWRITERS LABORATORIES (UL)

UL 10B	(2008; Reprint Apr 2009) Fire Tests of Door Assemblies

WINDOW AND DOOR MANUFACTURERS ASSOCIATION (WDMA)

WDMA I.S. 1-A	(2007) Architectural Wood Flush Doors
WDMA I.S. 4	(2009) Water-Repellent Preservative Non-Pressure Treatment for Millwork
WDMA I.S. 6	(2008) Wood Stile and Rail Doors
WDMA TM-7	(2008) Cycle Slam Test Method
WDMA TM-8	(2008) Hinge Loading Test Method

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

SD-02 Shop Drawings

Door Drawings; G

SD-03 Product Data

Doors
Warranty
Fire Resistance Rating; G

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver doors to the site in an undamaged condition and protect against damage and dampness. Stack doors flat under cover. Support on blocking, a minimum of 100 mm (4 inch) thick, located at each end and at the midpoint of the door. Store doors in a well-ventilated building so that they will not be exposed to excessive moisture, heat, dryness, direct sunlight, or extreme changes of temperature and humidity. Do not store in a building under construction until concrete, masonry work, and plaster are dry. Replace defective or damaged doors with new ones.

1.4 Shop Drawings

Submit door drawings or catalog data showing each type of door unit. Drawings and/or data shall indicate door type and construction, sizes, thickness, door louvers, and glazing.

1.5 WARRANTY

Warrant doors free of defects as set forth in the door manufacturer's standard door warranty. Submit one paper copy and one digital copy (.pdf - text searchable) of manufacturer's warranty.

PART 2 PRODUCTS

2.1 DOORS

Provide doors of the types, sizes, and designs indicated, free of urea-formaldehyde resins.

2.1.1 Stile and Rail Doors

Standard grade Ponderosa Pine doors or select standard stile and rail doors conforming to WDMA I.S. 6. Furnish laminate panels in not less than three ply thickness. Provide flat panels with a minimum finished panel thickness of 13 mm (1/2 inch) and 20 mm (3/4 inch) thickness for raised panels.

2.1.2 Flush Doors

Conform to WDMA I.S. 1-A or KS F 3109 for flush doors. Provide hollow core doors with lock blocks and 25 mm (1 inch) minimum thickness hinge stile. Hardwood stile edge bands of doors receive a natural finish, compatible with face veneer. Provide mill option for stile edge of doors scheduled to be painted. No visible finger joints will be accepted in stile edge bands. When used, locate finger-joints under hardware.

2.1.2.1 Interior Flush Doors

Provide hollow core, Type II flush doors conforming to WDMA I.S. 1-A or KS F 3109 with faces of sound grade hardwood or hardboard for painted finish, good grade natural birch, good grade red or white oak, or good grade walnut. Hardwood veneers shall be rotary cut or plain sliced random matched. Finish plastic laminate faced doors on both vertical edges with laminated plastic of color matching faces.

2.1.3 Bi-Fold Closet Doors

Provide hardboard grade flush doors conforming to WDMA I.S. 1-A or louvered doors standard grade, conforming to WDMA I.S. 6 with 35 mm (1-3/8 inch) thickness. Equip doors with the manufacturer's standard hardware, including tracks, hinges, guides, and pulls.

2.1.4 Sliding Closet Doors

Provide flush wood doors to conform to WDMA I.S. 1-A. Provide paneled and louvered doors to conform to WDMA I.S. 6 standard grade with 35 mm (1-3/8) inch thickness. Equip doors with the manufacturer's standard hardware.

2.1.5 X-Ray Resistant Doors

WDMA I.S. 1-A solid core flush doors, hardwood veneered, minimum 44.5 mm (1 3/4 inch) thick, of sizes and construction indicated. Provide lead sheets with 99.9 percent pure lead, 5 mm (3/16 inch) thickness, free from dross, oxide, inclusions, laminations, scale, blisters, and cracks. Locate lead sheets in accordance with manufacturer's standard, to extend fully from edge to edge, from top to bottom, and to be an integral part of the door. Provide wood edge strips compatible with face veneers.

2.1.6 Acoustical Doors

WDMA I.S. 1-A, solid core, constructed to provide Sound Transmission Class rating of 40 when tested in accordance with ASTM E90.

2.1.7 Fire Doors

Provide doors specified or indicated to have a fire resistance rating conforming to the requirements of UL 10B, ASTM E2226, or NFPA 252 for the class of door indicated. Affix a permanent metal label with raised or incised markings indicating testing agency's name and approved hourly fire rating to hinge edge of each door.

2.1.8 Prehung Doors

Frames for prehung interior doors to be for painted or clear finish, with 3 piece adjustable jamb units. Provide doors complete with frame, hinges, and prepared to receive finish hardware.

2.2 ACCESSORIES

2.2.1 Door Louvers

Fabricate from wood and of sizes indicated. Provide louvers with a minimum of 35 percent free air. Equip louvers with sight-proof inverted vee slat type. Block hollow core doors to provide solid anchorage for the louvers. Mount louvers in the door with flush wood moldings.

2.2.2 Door Light Openings

Provide glazed openings with the manufacturer's standard wood moldings. Provide moldings on the exterior doors with sloped surfaces.

2.2.3 Weather-stripping

Provide weather-stripping that is a standard cataloged product of a manufacturer regularly engaged in the manufacture of this specialized item. Provide weather-stripping tempered spring bronze or looped neoprene or vinyl held in an extruded non-ferrous metal housing. Install bronze weather-stripping with a minimum thickness of 0.23 mm (0.0089 inch) for sills, and a minimum thickness of 0.16 mm (0.0063 inch) elsewhere. Air leakage of weatherstripped doors not to exceed 0.0025 cubic meter per second of air per square meter (0.5 cubic feet per minute of air per square foot) of door area when tested in accordance with ASTM E283.

2.2.4 Additional Hardware Reinforcement

Provide the minimum lock blocks to secure the specified hardware. The measurement of top, bottom, and intermediate rail blocks are a minimum 125 mm 5 inch by full core width. Comply with the manufacturer's labeling requirements for reinforcement blocking, but not mineral material similar to the core.

2.3 FABRICATION

2.3.1 Marking

Stamp each door with a brand, stamp, or other identifying mark indicating quality and construction of the door.

2.3.2 Quality and Construction

Identify the standard on which the construction of the door was based and identify doors having a Type I glue bond.

2.3.3 Preservative Treatment

Treat doors scheduled for restrooms, janitor closets and other possible wet locations including exterior doors with a water-repellent preservative treatment and so marketed at the manufacturer's plant in accordance with WDMA I.S. 4.

2.3.4 Adhesives and Bonds

WDMA I.S. 1-A. Use Type I bond for exterior doors and Type II bond for interior doors. Provide a non-staining adhesive on doors with a natural finish.

2.3.5 Prefitting

Provide factory prefinished and factory prefitted doors for the specified hardware, door frame and door-swing indicated. Machine and size doors at the factory by the door manufacturer in accordance with the standards under which the doors are produced and manufactured. The work includes sizing, beveling edges, mortising, and drilling for hardware and providing necessary beaded openings for glass and louvers. Provide the door manufacturer with the necessary hardware samples, and frame and hardware schedules to coordinate the work.

2.3.6 Finishes

2.3.6.1 Field Painting

Factory prime or seal doors and field paint.

2.3.6.2 Factory Finish

Provide doors finished at the factory by the door manufacturer as follows: AWI AWS Section 1500, specification for System No. 4 Conversion varnish alkyd urea or System No. 5 Vinyl catalyzed. The coating is AWI AWS premium, medium rubbed sheen, open or closed grain effect. Use stain when required to produce the finish specified for color. Seal edges, cutouts, trim, and wood accessories, and apply two coats of finish compatible with the door face finish. Touch-up finishes that are scratched or marred, or where exposed fastener holes are filled, in accordance with the door manufacturer's instructions. Match color and sheen of factory finish using materials compatible for field application.

2.3.6.3 Plastic Laminate Finish

Factory applied, ANSI/NEMA LD 3, General or Specific purpose type, 1.25 mm (0.050 inch) minimum thickness. Glue laminated plastic for hollow core doors to wood veneer, plywood, or hardboard backing to form door panel. Provide a combined thickness of laminate sheet and backing of 2.5 mm (0.10 inch) minimum.

2.3.6.4 Color

Provide door finish colors as selected by the Contracting Officer from the color selection samples.

2.3.7 Water-Resistant Sealer

Provide manufacturer's standard water-resistant sealer compatible with the specified finishes.

2.4 SOURCE QUALITY CONTROL

Meet or exceed the following minimum performance criteria of stiles of "B" and "C" label fire doors utilizing standard mortise leaf hinges:

a. Cycle-slam: 200,000 cycles with no loose hinge screws or other visible signs of failure when tested in accordance with the requirements of WDMA TM-7.

b. Hinge loading resistance: Averages of ten test samples not less than 315 kilograms (700 pounds) load when tested for direct screw withdrawal in accordance with WDMA TM-8 using a No. 12, 30 mm (1-1/4 inch) long, steel, fully threaded wood screw. Drill 4 mm (5/32 inch) pilot hole, use 40 mm (1-1/2 inch) opening around screw for bearing surface, and engage screw full, except for last 3 mm (1/8 inch). Do not use a steel plate to reinforce screw area.

2.5 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Before installation, seal top and bottom edges of doors with the approved water-resistant sealer. Seal cuts made on the job immediately after cutting using approved water-resistant sealer. Fit, trim, and hang doors with a 2 mm (1/16 inch) minimum, 3 mm (1/8 inch) maximum clearance at sides and top, and a 5 mm (3/16 inch) minimum, 6 mm (1/4 inch) maximum clearance over thresholds. Provide 10 mm (3/8 inch) minimum, 11 mm (7/16 inch) maximum clearance at bottom where no threshold occurs. Bevel edges of doors at the rate of 3 mm in 50 mm (1/8 inch in 2 inch). Door warp shall not exceed 6 mm (1/4 inch) when measured in accordance with WDMA I.S. 1-A.

3.1.1 Fire and Smoke Doors

Install fire doors in accordance with NFPA 80. Install smoke doors in accordance with NFPA 105. Do not paint over labels.

3.1.2 Prehung Doors

Install doors in accordance with the manufacturer's instructions and details. Provide fasteners for stops within 75 mm (3 inch) of each end and spaced 279 mm (11 inch) on center maximum. Provide side and head jambs joined together with a dado or notch of 5 mm (3/16 inch) minimum depth.

3.1.3 Weather-stripping

Install doors in strict accordance with the door manufacturer's printed installation instructions and details. Weather-strip exterior swing-type doors at sills, heads and jambs to provide weathertight installation. Apply weather-stripping at sills to bottom rails of doors and hold in place with a brass or bronze plate. Apply weather-stripping to door frames at jambs and head. Shape weather-stripping at sills to suit the threshold. Meeting stiles of exterior double-doors shall be made weathertight by means of a neoprene, vinyl or spring-bronze weatherstripped astragal secured to the inactive door leaf, unless otherwise indicated.

3.2 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Closet doors	1-1/8 inch	28.5 mm
	1-3/8 inch	35 mm
X-Ray resistant doors	1-3/4 inch	44.5 mm
	2 inches	50 mm
	2-1/4 inch	57 mm
	2-1/2 inch	64 mm
Weather-stripping	0.0089 inch	0.23 mm
	0.0063 inch	0.16 mm

-- End of Section --

SECTION 08 33 13

METAL ROLLING COUNTER DOORS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2014) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(2013) Standard for Fire Doors and Other Opening Protectives

1.2 SYSTEM DESCRIPTION

Furnish rolling counter doors of the type, size, and design indicated on the drawings. Provide the standard product of a manufacturer regularly engaged in the production of rolling counter doors. Provide each door with a permanent label showing the manufacturer's name and address and the model number of the door. Submit Manufacturer's descriptive data and catalog cuts.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When

used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Rolling Counter Doors
Rolling Counter Door (Non-Rated)
Fire-Rated Rolling Counter Door

SD-10 Operation and Maintenance Data

Rolling Counter Doors (Non-Rated)
Fire-Rated Rolling Counter Doors
Cleaning

1.4 QUALITY ASSURANCE

Submit Detail Drawings showing elevations of each door type, details of anchorage, details of construction, location and description of hardware, shape and thickness of materials, details of joints and connections, and details of guides and fittings. Include a schedule showing the location of each counter door with the drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver rolling counter doors to the jobsite wrapped in a protective covering with the brands and names clearly marked thereon. Store rolling counter doors in accordance with the manufacturer's instructions in a dry location that is adequately ventilated and free from dust, water, or other contaminants, and in a manner that permits easy access for inspecting and handling. Handle doors carefully to prevent damage. Replace damaged items that cannot be restored to like-new condition.

1.6 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period.

PART 2 PRODUCTS

2.1 BASIC COMPONENTS

2.1.1 Curtain

Fabricate the curtain of extruded aluminum slats conforming to ASTM B221M (ASTM B221), Alloy 6063, or 0.759 mm (22 gauge) Type 304 stainless steel slats conforming to ASTM A240/A240M, Type 304 or Type 430, or 0.759 mm (22 gauge) galvanized steel slats conforming to ASTM A653/A653M, Coating Designation G60, as designed. Provide thickness of slat material as required by width of opening or as required by specified fire-rating. Use slats approximately 32 to 38 mm (1-1/4 to 1-1/2 inch) wide with a depth of crown of 13 mm (1/2 inch). Fit alternate slats with end locks to maintain curtain alignment. Provide bottom of curtain with angle or tubular bar reinforcement matching the curtain, and fitted with a resilient bottom seal.

2.1.2 Jamb Guides

Furnish guides of 3 mm (1/8 inch) minimum thickness extruded aluminum conforming to ASTM B221M (ASTM B221), Alloy 6063, and fitted with neoprene silencers or replaceable heavy nap striping to eliminate noise and dust infiltration, or 2.278 mm (13 gauge) minimum thickness stainless steel conforming to ASTM A240/A240M, Type 304 or Type 430, or 2.278 mm (13 gauge) minimum thickness galvanized steel angles conforming to ASTM A653/A653M, Coating Designation G60.

2.1.3 Counterbalance Shaft Assembly

Furnish the curtain coiled around a steel tube of sufficient thickness and diameter to prevent deflection exceeding 2.5 mm per meter (0.03 inch per foot). Provide a barrel containing oil tempered helical steel torsion springs capable of sufficient torque to counterbalance the weight of the curtain. Calculate the springs to provide a minimum of 7,500 operating cycles (one complete cycle of door operation will begin with the door in the closed position, move to the full open position and return to the closed position).

2.1.4 Brackets

Furnish brackets of a minimum 2.657 mm (12 gauge) thickness steel if flat plate, or 1.519 mm (16 gauge) thickness if there are a minimum of 3 returns of 19 mm (3/4 inch) width.

2.1.5 Hood

Provide a hood of 1.02 mm (0.040 inch) minimum thickness aluminum sheet conforming to ASTM B209M (ASTM B209), Alloy 5005, or 0.607 mm (24 gauge) stainless steel conforming to ASTM A240/A240M, Type 304 or Type 430, or 0.607 mm (24 gauge) galvanized steel conforming to ASTM A653/A653M, Coating Designation G60.

2.1.6 Locks

Lock the curtain at each side of the bottom bar by an integral slide bolt suitable for padlocks by others, or both sides of bottom bar by a chrome-plated cylinder lock keyed into the building keying system. Locate lock on the room side of the counter door. Provide pad locks and keying conforming to Section 08 71 00 DOOR HARDWARE.

2.2 ROLLING COUNTER DOOR (NON-RATED)

Construct rolling counter doors, curtains, guides and hood components of aluminum, stainless steel, or galvanized steel conforming to the requirements specified herein.

2.3 FIRE-RATED ROLLING COUNTER DOOR

Furnish fire-rated rolling counter doors, Class A (3 hr.), Class B (1-1/2 hr.), Class C (3/4 hr.), or Class D (1-1/2 hr.) rated as shown and conforming to the requirements specified and to NFPA 80 for the class indicated. Provide labels of a recognized testing agency for the doors, indicating the applicable fire resistance rating. The construction details necessary for labeled rolling counter doors will take precedence over details indicated or specified herein. Furnish door curtains, guides and hood of stainless steel or galvanized steel as indicated. Provide fire-rated rolling counter doors complete with hardware, accessories, and automatic closing device. Provide rolling counter doors, in exit corridor walls, with perimeter smoke and draft control gasketing.

2.4 INTEGRAL FRAME ROLLING COUNTER DOOR (RATED OR NON-RATED)

Furnish integral frame rolling counter door of aluminum (non-rated only, stainless steel, galvanized steel as indicated. Class A (3 hr.), Class B (1-1/2 hr.), Class C (3/4 hr.), or Class D (1-1/2 hr.) as shown, stainless steel or galvanized steel as indicated. Fire-rated doors must conform with the requirements of NFPA 80 for the Class indicated and bearing the labels of a recognized testing agency indicating the applicable fire resistance rating. Form jambs to create guides for the curtain. Provide head and jambs of 1.519 mm (16 gauge) thickness. Provide counter of 1.894 mm (14 gauge) thickness. Provide rolling counter doors, in exit corridor walls, with perimeter smoke and draft control gasketing.

2.5 AUTOMATIC CLOSING DEVICE

Equip fire-rated counter doors with an automatic closing device which operates upon activation of the building's fire alarm system, smoke alarm system, or heat detector system. Furnish fire and smoke doors that easily reset by the facility user after they have been released by the detection system. Resetting the door shall not require the use of special tools.

2.6 FINISH

Exposed parts of the counter door, including the curtain, bottom rail, guides, and hood shall be of uniform finish and appearance. Furnish aluminum with a clear anodized finish, stainless steel with a No. 4 finish, or steel galvanized coating with a prime coat and a baked-on or powder-coated Factory top coat finish as indicated. Give all other steel parts a shop coat of primer paint standard with the manufacturer. Provide a factory coated color as selected by the Contracting Officer from the color selection samples.

2.7 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Install doors in accordance with approved detail drawings and manufacturer's instructions. Accurately locate anchors and inserts for guides, brackets, hardware, and other accessories. Upon completion, doors shall be free from warp, twist, or distortion. Lubricate, properly adjust, and demonstrate doors to operate freely. Fire-door installation will conform with NFPA 80 for the class indicated and the manufacturer's instructions.

3.2 OPERATION

3.2.1 Manual Operation

Provide curtain operated by means of manual push-up with lift handles or continuous full width lift bar, or manual crank with removable handle.

3.2.2 Power Operation

Furnish a high-starting torque, reversible type motor of sufficient power and torque output to move the door in either direction from any position at the required speed. Provide power operator with an emergency push-up operation, limit switch, three-button type control marked "OPEN", "CLOSE", and "STOP". Provide control voltage of 24 vac or 120 vac. Provide conduit and wiring necessary for proper operation in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.3 TESTS

Drop-test the fire doors in accordance with NFPA 80 to show proper operation and full automatic closure and reset in accordance with the manufacturer's instructions. Provide a written record of initial test to the Contracting Officer.

3.4 FIELD FINISHING

Doors to receive field finishing shall be factory primed, as required, and then finished in accordance with Section 09 90 00 PAINTS AND COATINGS. Provide color as selected by the Contracting Officer from the color selection samples.

3.5 CLEANING AND MAINTENANCE

Clean aluminum and stainless steel doors in accordance with manufacturer's approved instructions. Submit Manufacturer's preprinted installation and cleaning instructions.

Submit one hard copy and one digital (.pdf - text searchable) copy of Data Package 2 for Rolling Counter Doors (Non-Rated) and Fire-Rated Rolling Counter Doors in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide a list of the parts recommended by the manufacturer to be replaced after 1 year and 3 years of service.

-- End of Section --

SECTION 08 33 23

OVERHEAD COILING DOORS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-10	(2010; Change 2010; Change 2011; Errata 2011; Change 2011) Minimum Design Loads for Buildings and Other Structures

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE FUN IP	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, I-P Edition

ASME INTERNATIONAL (ASME)

ASME B29.400	(2001; R 2008) Combination, "H" Type Mill Chains, and Sprockets

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A27/A27M	(2010) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A666	(2010) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM E330	(2002; R 2010) Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F568M	(2007) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2014) Motors and Generators
NEMA ST 1	(1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata

	3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 80	(2013) Standard for Fire Doors and Other Opening Protectives

UNDERWRITERS LABORATORIES (UL)

UL 674	(2011; Reprint Jul 2013) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL Bld Mat Dir	(2012) Building Materials Directory

1.2 DESCRIPTION

Overhead coiling doors to be counterbalanced doors by methods of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed or self-lubricating bearings for rotating members. Doors to be coiling type, with interlocking slats, complete with anchoring and door hardware, guides, hood, and operating mechanisms, and designed for use on openings as indicated.

Fire-rated door assemblies must bear the Underwriters Laboratories, Warnock Hersey, Factory Mutual or other nationally recognized testing laboratory label for the rating listed on the drawings. Provide a permanent label for each door showing the manufacturer's name and address and the model/serial number of the door.

Oversized fire-rated door assemblies must be provided with a listing agency oversize label, or a certificate signed by an official of the manufacturing company certifying that the door and operator have been designed to meet the specified requirements.

1.3 PERFORMANCE REQUIREMENTS

1.3.1 Wind Loading

Design and fabricate door assembly to withstand the wind loading pressure of at least 0.96 kilopascal (20 pounds per square foot) with a maximum deflection of 1/120 of the opening width. Provide test data showing compliance with ASTM E330. Sound engineering principles may be used to interpolate or extrapolate test results to door sizes not specifically tested. Completed assembly must meet or exceed the requirements of ASCE 7-10.

1.3.2 Fire-Rated Doors, Frames, and Hardware

Provide fire-rated doors, frames, and hardware which are tested, rated, and labeled in accordance with Underwriters Laboratories, Factory Mutual or Warnock Hersey. The labels must indicate the rating in hours, per NFPA 80 of duration of exposure to fire, with a letter following the hourly rating to designate the location for which the assembly is designed and the temperature rise on the unexposed face of the door at the end of 30 minutes of fire exposure.

Provide and attach metal UL labels to each item of hardware in accordance with requirements specified in the UL Bld Mat Dir.

1.3.3 Oversized Coiling Fire-rated Door Assemblies

Where fire-rated doors and frames exceed the size for which testing and labeling services are offered, furnish certificates of inspection from the UL, Factory Mutual or Warnock Hersey. State within certificates that except for size; doors, frames, and hardware are identical in design, materials, and construction to a door that has been tested and rated.

1.3.4 Operational Cycle Life

All portions of the door, hardware and operating mechanism that are subject to movement, wear, or stress fatigue must be designed to operate through a minimum number of 10 cycles per day. One complete cycle of door operation is defined as when the door is in the closed position, moves to the fully open position, and returns to the closed position.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead Coiling Door Detail Drawings

SD-03 Product Data

Overhead Coiling Doors
Warranty
Hardware
Counterbalancing Mechanism
Manual Door Operators
Electric Door Operators
Fire-Rated Door Assembly

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.5 OVERHEAD COILING DOOR DETAIL DRAWINGS

Provide fabrication and installation drawings for overhead coiling door assemblies which show elevations of each door type, shape and thickness of materials, finishes, details of joints and connections, details of guides and fittings, rough opening dimensions, location and description of hardware, anchorage locations, hardware and framing details, and counterbalancing mechanism and door operator details. Show locations of replaceable fusible links wiring diagrams for power, signal and controls. Include a schedule showing the location of each door with the drawings.

1.6 WARRANTY

Contractor must furnish a written guarantee that the helical spring and counterbalance mechanism are free from defects in material and workmanship and that they will remain so for not less than two years after completion and acceptance of the project.

Contractor must warrant that upon notification by the Government, he will immediately make good any defects in material, workmanship, and door operation within the same time period covered by the guarantee, at no cost to the Government.

Contractor must submit one hard copy and one digital copy (.pdf - text searchable) of the Operation and Maintenance Manuals 30 calendar days prior to testing the Overhead Coiling Door Assemblies. Provide operation and maintenance manuals which are consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion. Provide test data that is legible and of good quality. Include materials, devices, procedures, manufacturers' brochures, parts lists, and cleaning.

1.7 DELIVERY AND STORAGE

Delivered doors to the jobsite wrapped in a protective covering with the brands and names clearly marked thereon. Store doors in a dry location that is adequately ventilated and free from dirt and dust, water, and other contaminants, and in a manner that permits easy access for inspection and handling.

PART 2 PRODUCTS

2.1 OVERHEAD COILING DOORS

2.1.1 Curtain Materials and Construction

Fabricate doors from interlocking cold-rolled slats, with section profiles as specified, designed to withstand the specified wind loading. Provide slats which are continuous without splices for the width of the door.

If indicated on contract drawings, provide slats filled with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E84. Enclose insulation completely within slat faces on interior surface of slats.

Curtain shall be constructed from one of the following curtain materials as indicated:

a. Provide curtain slats which are fabricated from steel sheets conforming to ASTM A653/A653M, Grade A, with the additional requirement of a minimum yield point of 228 Megapascal. (33,000 psi.) Provide sheets which are galvanized in accordance with ASTM A653/A653M and ASTM A924/A924M, or

b. Provide curtain slats which are fabricated from Stainless steel sheets conforming to ASTM A666, Type 304; sheet thickness of 0.64 mm (0.025 inch) and as required to meet requirements, or

c. Provide curtain slats which are fabricated from aluminum sheets conforming to ASTM B209 (ASTM B209M) sheet or ASTM B221 (ASTM B221M) extrusions, alloy and temper standard with manufacturer for type of use and finish indicated; thickness of 1.27 mm (0.050 inch) and as required to meet requirements

2.1.2 Non-Insulated Curtains

Form Curtains from manufacturer's standard shapes of interlocking slats.

2.1.3 Insulated Curtains

Form Curtains from manufacturer's standard shapes of interlocking slats. Supply slat system with a minimum R-value of 4 when calculated in accordance with ASHRAE FUN IP. Slats to consist of a urethane core not less than 17 mm (11/16 inch) thick, completely enclosed within metal facings. Exterior face of slats must be the same gauge as specified for curtains. Interior face must be not lighter than 0.56 mm (0.0219 inches). The insulated slat assembly is to have a flame spread rating of not more than 25 and a smoke development factor of not more than 50 when tested in accordance with ASTM E84.

2.1.4 Curtain Bottom Bar

Curtain bottom bars must be pairs of angles from the manufacturer's standard steel, stainless and aluminum extrusions not less than 50 by 50 millimeter by 4.8 millimeter. (2.0 by 2.0 inches by 0.188 inch.) Steel extrusions must conform to ASTM A36/A36M. Stainless steel extrusions conforming to ASTM A666, Type 304. Aluminum extrusions conforming to ASTM B221 or (ASTM B221M). Galvanize angles and fasteners in accordance with ASTM A653/A653M and ASTM A924/A924M. Coat welds and abrasions with paint conforming to ASTM A780/A780M.

2.1.5 Vision Panels

Provide complete manufacturer's standard vision panels assembly consist of clear acrylic glazing panels or fire-rated glass as required for the type door set in a neoprene channel with a galvanized-steel frame not less than 0.91 millimeter (0.0359-inch) uncoated thickness.

2.1.6 Locks

Provide end and/or wind locks of cast steel conforming to ASTM A27/A27M, Grade B; galvanized in accordance with ASTM A653/A653M, ASTM A153/A153M and ASTM A924/A924M and secured at every other curtain slat.

2.1.7 Weather Stripping

Weather-stripping at the door-head and jamb must be 3.2 millimeter (1/8-inch) thick sheet of natural or neoprene rubber with air baffles, secured to the insides of hoods with galvanized-steel fasteners through continuous galvanized-steel pressure bars at least 15.9 millimeter (5/8-inch) wide and 3.2 millimeter(1/8-inch thick).

Threshold weather-stripping must be 3.2 millimeters (1/8-inch) thick sheet natural or neoprene rubber secured to the bottom bars.

Provide weather-stripping of natural or neoprene rubber conforming to ASTM D2000.

2.1.8 Locking Devices

Slide Bolt to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.

Locking Device Assembly which includes cylinder lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bars to engage through slots in tracks.

2.1.9 Safety Interlock

Equip power-operated doors with safety interlock switch to disengage power supply when door is locked.

2.1.10 Overhead Drum

Provide one of the following overhead drums to match with slat material:

a. Fabricate drums from nominal 0.71-mm (0.028-inch) thick, hot-dip galvanized steel sheet with G90 (Z275) zinc coating, complying with ASTM A653/A653M.

b. Fabricate drums from nominal 0.64-mm (0.025-inch) thick stainless-steel sheet, Type 304, complying with ASTM A666.

c. Fabricate drums from nominal 1.02-mm (0.040-inch) thick aluminum sheet complying with ASTM B209 (ASTM B209M), of alloy and temper recommended by manufacturer and finish for type of use and finish indicated.

2.2 HARDWARE

All hardware must conform to ASTM A153/A153M, ASTM A307, ASTM F568M, and ASTM A27/A27M.

2.2.1 Guides

Fabricate curtain jamb guides from the manufacturer's standard angles or channels of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for track adjustment.

2.2.2 Equipment Supports

Fabricate door-operating equipment supports from the manufacturer's standard steel shapes and plates conforming to ASTM A36/A36M, galvanized in accordance with ASTM A653/A653M and ASTM A924/A924M. Size the shapes and plates in accordance with the industry standards for the size, weight, and type of door installation.

2.3 COUNTERBALANCING MECHANISM

Counterbalance doors by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed or self-lubricating bearings for rotating members.

2.3.1 Brackets

Provide the manufacturer's standard mounting brackets of either cast iron or cold-rolled steel with one located at each end of the counterbalance barrel conforming to ASTM A48/A48M.

2.3.2 Counterbalance Barrels

Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, welded or seamless carbon-steel pipe, conforming to ASTM A53/A53M, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 2.5 mm per meter (0.03 inch per foot) of span under full load.

2.3.3 Spring Balance

One or more oil-tempered, heat-treated steel helical torsion springs installed within the barrel capable of producing sufficient torque to assure easy operation of the door curtain. Provide and size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.

2.3.4 Torsion Rod for Counter Balance

Fabricate rod from the manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.

2.4 MANUAL DOOR OPERATORS

2.4.1 Manual Push-Up Door Operators

Equip door with manufacturer's recommended lifting handles, locks, and latches. Adjust counterbalance mechanisms so that the required lift or pull for operation does not exceed 11 kilogram (25 pounds) unless another type of door operator is indicated. Design operating mechanisms so that the curtain can be stopped at any point in its upward or downward travel and will remain in that position until pushed to the fully open or closed position.

2.4.2 Manual Chain-Hoist Door Operators

Provide door operators which consist of an endless steel hand chain, chain-pocket wheel, guard, and a geared reduction unit with a maximum 111 N (25 lbf) required pull for operation must not exceed 16 kilogram (35 pounds).

Provide chain hoists to have a self-locking mechanism allowing the curtain to be stopped at any point in its upward or downward travel and to remain in that position until moved to the fully open or closed position. Provide hand chains of cadmium-plated alloy steel conforming to ASME B29.400. Yield point of the chain must be at least three times the required hand-chain pull.

Provide chain sprocket wheels of cast iron conforming to ASTM A48/A48M.

2.4.3 Manual Crank-Hoist Door Operators

Provide door operators which consist of crank and crank gearbox, steel crank drive shaft, and gear-reduction unit with a maximum 111 N (25 lbf) force to turn crank. Fabricate gearbox to be oil tight and to completely enclose operating mechanism. Provide manufacturer's standard crank-locking device having a self-locking mechanism allowing the curtain to be stopped at any point in its upward or downward travel and remain in that position until moved to the fully open or closed position.

2.5 ELECTRIC DOOR OPERATORS

Provide electrical wiring and door operating controls conforming to the applicable requirements of NFPA 70.

Electric door-operator assemblies must be the sizes and capacities recommended and provided by the door manufacturer for specified doors. Assemblies must be complete with electric motors and factory-prewired motor controls, starter, gear reduction units, solenoid-operated brakes, clutch, remote-control stations, manual or automatic control devices, and accessories as required for proper operation of the doors.

Design the operators so that motors may be removed without disturbing the limit-switch adjustment and affecting the emergency auxiliary operators.

Provide a manual operator of crank-gear or chain-gear mechanisms with a release clutch to permit manual operation of doors in case of power failure. Arrange the emergency manual operator so that it may be put into and out of operation from floor level and its use will not affect the adjustment of the limit switches. Provide an electrical or mechanical device which will automatically disconnect the motor from the operating mechanism when the emergency manual operating mechanism is engaged.

2.5.1 Door-Operator Types

Provide one of the following as indicated on contract drawings.

a. Provide an operator which is mounted to the right or left door head plate with the operator on top of the door-hood assembly and connected to the door drive shaft with drive chain and sprockets. Headroom is required for this type of mounting.

b. Provide an operator which is mounted to the right or left door head plate with the operator on coil side of the door-hood assembly and connected to the door drive shaft with drive chain and sprockets. Front clearance is required for this type of mounting.

c. Provide an operator which is mounted to the inside front wall on the left or right side of door and connected to door drive shaft with drive chain and sprockets. Side room is required for this type of mounting. Wall mounted operator can also be mounted above or below shaft; if above shaft, headroom is required.

d. Provide a bench mounted operator which is mounted to the right or left door head plate and connected to the door drive shaft with drive chain and sprockets. Side room is required for this type of mounting.

e. Provide a through-wall operator which is mounted on other side of wall from coil side of door.

2.5.2 Electric Motors

Provide motors which are the high-starting-torque, reversible, constant-duty electrical type with overload protection of sufficient torque and wattage (horsepower) to move the door in either direction from any position and produce a door-travel speed of not less than 0.2 or more than 0.3 meter (8 or more than 12 inches) per second without exceeding the wattage (horsepower) rating.

Provide motors which conform to NEMA MG 1 designation, temperature rating, service factor, enclosure type, and efficiency to the requirements specified.

Certify and label explosion-proof motors to indicate conformance to the following:

UL 674, Class I, Groups C and D

UL 674, Class II, Groups F and G

2.5.3 Motor Bearings

Bearings must be bronze-sleeve or heavy-duty ball or roller antifriction type with full provisions for the type of thrust imposed by the specific duty load.

Pre-lubricate and factory seal bearings in motors less than 375 watts (1/2 horsepower).

Equip motors coupled to worm-gear reduction units with either ball or roller bearings.

Equip bearings in motors 375 watts (1/2 horsepower) or larger with lubrication service fittings. Fit lubrication fittings with color-coded plastic or metal dust caps.

In any motor, bearings that are lubricated at the factory for extended duty periods do not need to be lubricated for a given number of operating hours. Display this information on an appropriate tag or label on the motor with instructions for lubrication cycle maintenance.

2.5.4 Motor Starters, Controls, and Enclosures

Each door motor must have a factory-wired, unfused, disconnect switch; a reversing, across-the-line magnetic starter with thermal overload protection; 120-volt operating coils with a control transformer limit switch; and a safety interlock assembled in a NEMA ICS 6 type enclosure as specified herein. Control equipment must conform to NEMA ICS 2.

Provide adjustable switches, electrically interlocked with the motor controls and set to stop the door automatically at the fully open and fully closed position.

2.5.5 Control Enclosures

Provide control enclosures that conform to NEMA ICS 6 for general purpose NEMA Type 1, unless otherwise indicated.

2.5.6   Transformer

Provide starters with 230/460 to 115 volt control transformers with one secondary fuse when it is required to reduce the voltage on control circuits to 120 volts or less. Provide transformer that conforms to NEMA ST 1.

2.5.7   Safety-Edge Device

Provide each door with a pneumatic safety device extending the full width of the door and located within a U-section neoprene or rubber astragal mounted on the bottom rail of the bottom door section. Device must immediately stop and reverse the door upon contact with an obstruction in the door opening during downward travel and cause the door to return to full-open position. Safety device is not a substitute for a limit switch.

Connect safety device to the control circuit through a retracting safety cord and reel.

2.5.8   Remote-Control Stations

Provide interior remote control stations which are full-guarded, momentary-contact three-button, heavy-duty, surface-mounted NEMA ICS 6 type enclosures as specified. Mark buttons "OPEN," "CLOSE," and "STOP." The "CLOSE" button must be the type requiring a constant pressure to maintain the closing motion of the door. When the door is in motion and the "STOP" button is pressed, the door must stop instantly and remain in the stopped position; from the stopped position, the door may then be operated in either direction.

2.5.9   Speed-Reduction Units

Provide speed-reduction units consisting of hardened-steel worm and bronze worm gear assemblies running in oil or grease and encased in a sealed casing, coupled to the motor through a flexible coupling. Drive shafts must rotate on ball- or roller-bearing assemblies that are integral with the unit.

Provide minimum ratings of speed reduction units which are in accordance with AGMA provisions for class of service.

Ground worm gears to provide accurate thread form; machine teeth for all other types of gearing. Surface harden all gears.

Provide bearings which are the antifriction type equipped with oil seals.

2.5.10   Chain Drives

Provide roller chains that are power-transmission series steel roller type conforming to ASME B29.400, with a minimum safety factor of 10 times the design load.

Roller-chain side bars, rollers, pins, and bushings must be heat-treated or otherwise hardened.

Provide chain sprockets that are high-carbon steel with machine-cut hardened teeth, finished bore and keyseat, and hollow-head setscrews.

2.5.11 Brakes

Provide brakes which are 360-degree shoe brakes or shoe and drum brakes, solenoid-operated and electrically interlocked to the control circuit to set automatically when power is interrupted.

2.5.12 Clutches

Clutches must be the 100 millimeter (4-inch) diameter, multiple face, externally adjustable friction type or adjustable centrifugal type.

2.6 FIRE-RATED DOOR ASSEMBLY

Provide fire-rated door assemblies with the dimensions, fire rating, and operating type indicated with electric operators and assemblies that do not interfere with manufacturer's standard interconnecting fusible links.

Provide door manufacturer's standard interconnecting fusible links for door assemblies on both sides of the wall opening.

2.6.1 Fire Ratings

Provide fire-rated door assemblies complying with NFPA 80 Standard for Fire Doors and Other Opening Protectives and UL Fire Resistance - Volume 3.

2.7 SURFACE FINISHING

Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Noticeable variations in the same metal component are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved samples and are assembled or installed to minimize contrast.

2.8 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 GENERAL

Install overhead coiling door assembly, anchors and inserts for guides, brackets, motors, switches, hardware, and other accessories in accordance with approved detail drawings and manufacturer's written instructions. Upon completion of installation, doors must be free from all distortion.

Install overhead coiling doors, motors, hoods, and operators at the mounting locations as indicated for each door in the contract documents and as required by the manufacturer.

Install overhead coiling doors, switches, and controls along accessible routes in compliance with regulatory requirements for accessibility and as required by the manufacturer.

3.2 FIELD PAINTED FINISH

Steel doors and frames which are to be field painted must accordance with Section 09 90 00 PAINTS AND COATINGS and manufacturer's written instructions. Protect weather stripping from paint. Finishes must be free of scratches or other blemishes.

3.3 ACCEPTANCE PROVISIONS

After installation, adjust hardware and moving parts. Lubricate bearings and sliding parts as recommended by manufacturer to provide smooth operating functions for ease movement, free of warping, twisting, or distortion of the door assembly.

Adjust seals to provide weather-tight fit around entire perimeter.

Engage a factory-authorized service representative to perform startup service and checks according to manufacturer's written instructions.

Test the door opening and closing operation when activated by controls or alarm-connected fire-release system. Adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Reset door-closing mechanism after successful test.

Test and make final adjustment of new doors at no additional cost to the Government.

3.3.1 Maintenance and Adjustment

Not more than 90 calendar days after completion and acceptance of the project, the Contractor must examine, lubricate, test, and re-adjust doors as required for proper operation.

3.3.2 CLEANING

Clean aluminum or stainless steel doors in accordance with manufacturer's approved instructions.

-- End of Section --

SECTION 08 36 13

SECTIONAL OVERHEAD DOORS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A227/A227M	(2006; R 2011) Standard Specification for Steel Wire, Cold-Drawn for Mechanical Springs
ASTM A229/A229M	(1999; R 2005) Standard Specification for Steel Wire, Oil-Tempered for Mechanical Springs
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM C1363	(2011) Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box

Apparatus

ASTM E330 (2002; R 2010) Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

DOOR AND ACCESS SYSTEM MANUFACTURERS ASSOCIATION (DASMA)

ANSI/DASMA 102 (2004) Specifications for Sectional Overhead-Type Doors

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM AMP 500 (2006) Metal Finishes Manual

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1 (2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements

NEMA ICS 2 (2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 6 (1993; R 2011) Enclosures

NEMA MG 1 (2014) Motors and Generators

NEMA ST 20 (1992; R 1997) Standard for Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 325 (2002; Reprint Jan 20121) Door, Drapery, Gate, Louver, and Window Operators and Systems

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

SD-02 Shop Drawings

Drawings; G

SD-03 Product Data

Doors
Electric operators

SD-08 Manufacturer's Instructions

Installation Instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance

1.3 DRAWINGS

Submit shop drawings showing types, sizes, locations, metal gages including minimum metal decimal thickness, hardware provisions, installation details, and other details of construction. For electrically-operated doors, include supporting brackets for motors, location, type, and ratings of motors, switches, and safety devices.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect doors and accessories from damage during delivery, storage, and handling. Clearly mark manufacturer's brand name. Store doors in dry locations with adequate ventilation, free from dust and water. Remove damaged items and provide new. Provide easy access for inspection and handling of overhead doors prior to installation.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Hard-Drawn Springwire

ASTM A227/A227M.

2.1.2 Oil-Tempered Springwire

ASTM A229/A229M.

2.1.3 Steel Sheet

ASTM A653/A653M.

2.1.4 Steel Shapes

ASTM A36/A36M.

2.1.5 Aluminum Extrusions

ASTM B221M (ASTM B221), Alloy 6063-T5.

2.1.6 Aluminum Sheets and Strips

ASTM B209M (ASTM B209), alloy and temper best suited for the purpose.

2.1.7 Glass

Fully tempered, clear float glass 3 mm (1/8 inch) thick, unless otherwise indicated.

2.2 DOORS

ANSI/DASMA 102. Commercial doors. Metal doors to have horizontal sections hinged together which operate in a system of tracks to completely close the door opening in the closed position and make the full width and height of the door opening available for use in the open position. Provide a permanent label on the door indicating the name and address of the manufacturer. Provide doors with standard lift type designed to slide up and back into a horizontal overhead position and requiring a maximum of 400 mm (16 inch) of headroom for 50 mm (2 inch) tracks and 535 mm (21 inch) of headroom for 75 mm (3 inch) tracks, or low headroom type designed to slide up and back into a horizontal overhead position and requiring a maximum of 250 mm (10 inch) of headroom for 50 mm (2 inch) tracks and 300 mm (12 inch) of headroom for 75 mm (3 inch) tracks, or high lift type designed to slide up and back into a combination vertical and horizontal position, or vertical lift type designed to slide upward into a vertical position. Doors operate by lifting handles, by hand chain with gear or sprocket reduction, by hand crank with gear or sprocket reduction, or by electric power with auxiliary hand chain operation.

2.3 DESIGN REQUIREMENTS

Doors shall conform to ANSI/DASMA 102. Design wind load shall conform to the design mind load for the building except that doors, hardware, and anchors shall be designed to withstand a wind pressure of 0.96 kilopascals (20 pounds per square foot) of door area without damage. Provide doors to remain operable and undamaged after conclusion of tests conducted in accordance with ASTM E330 using the design wind load.

2.4 FABRICATION

2.4.1 Steel Overhead Doors

Form door sections of hot-dipped galvanized steel not lighter than 1.5 mm thick (16 gage) with flush surface without ribs or grooves, or 0.9 mm thick (20 gage) with longitudinal integral reinforcing ribs, or 0.6 mm thick (24 gage) with longitudinal integral reinforcing ribs and flat bottom V-grooves. Install sections not less than 50 mm (2 inch) in thickness. Meeting rails to have interlocking joints to ensure a weathertight closure and alignment for full width of the door. Provide sections of the height indicated or the manufacturer's standard. Do not exceed 600 mm thick (24 inch) height for intermediate sections. Bottom sections may be varied to suit door height. Do not exceed 750 mm (30 inch) height for bottom section. Provide glass panels and install panels using manufacturer's standard for rubber gaskets.

2.4.1.1 Insulated Sections

Insulate door sections with plastic foam or other material providing a "U" factor of 0.14 or less when tested in accordance with ASTM C1363. Cover interior of door sections with steel sheets of not lighter than 0.6 mm thick (24 gage) to completely enclose the insulating material.

2.4.1.2 Aluminum Sections

At the Contractor's option, door sections may be constructed of aluminum in lieu of steel. Provide the same structural and thermal properties for aluminum sections as specified for steel sections.

2.4.2 Aluminum Panel Overhead Doors

Provide door panel construction with extruded aluminum stiles and rails with aluminum (and glass) panels. Stiles and rails have a minimum wall thickness of 1.5 mm (0.060 inch). Meeting rails shall have interlocking joints to ensure a weathertight closure and alignment for full width of door. Provide sections to the height indicated or the manufacturer's standard, but the height of an intermediate section not to exceed 600 mm (24 inch). Bottom sections may be varied to suit door height, but to not exceed 750 mm (30 inch) in height. Provide aluminum panels not less than 1.0 mm (0.040 inch) in thickness. Install panel using a continuous vinyl gasket and snap-in type of aluminum or vinyl glazing bead. Install glass panels as specified for aluminum panels.

2.4.3 Tracks

Provide galvanized steel tracks not lighter than 1.8 mm thick for 50 mm (14 gage for 2 inch) tracks and not lighter than 2.5 mm thick for 75 mm (12 gage for 3 inch) tracks. Provide vertical tracks with continuous steel angle not lighter than 2.1 mm thick (13 gage) for installation to walls. Incline vertical track through use of adjustable brackets to obtain a weathertight closure at jambs. Reinforce horizontal track with galvanized steel angle; support from track ceiling construction with galvanized steel angle and cross bracing to provide a rigid installation.

2.4.4 Hardware

Provide hinges, brackets, rollers, locking devices, and other hardware required for complete installation. Install roller brackets and hinges with 14 gage galvanized steel. Provide rollers with ball bearings and case-hardened races. Provide reinforcing on doors where roller hinges are connected. Provide a positive locking device and cylinder lock with two keys on manually operated doors.

2.4.5 Counterbalancing

Counterbalance doors with an oil-tempered, helical-wound torsional spring mounted on a steel shaft. Provide adjustable spring tension and connect spring to doors with cable through cable drums. Provide cable safety factor of at least 5 to 1.

2.5 MANUAL OPERATORS

2.5.1 Pushup Operators

Provide lifting handles on both sides of door. Do not exceed the maximum lifting force of 11.25 kilograms (25 pounds) required to operate the door. Provide pull down straps or ropes at bottom of doors over 2130 mm (7 feet) high.

2.5.2 Chain Hoist Operators

Provide a galvanized, endless chain operating over a sprocket. Extend chain to within 1200 mm (4 feet) of the floor and mount on inside of building. Obtain reduction by use of roller chain and sprocket drive or gearing. Provide chain cleat and pin for securing operator chain. Allow for future installation of power operators to chain hoist operator. Do not exceed the maximum lifting force of 15.75 kilograms (35 pounds) required to operate the door.

2.6 ELECTRIC OPERATORS

Submit manufacturer's catalog data and wiring diagrams for motor and controls.

2.6.1 Operator Features

Operators shall be labeled and listed to the requirements of UL 325. Provide operators of the drawbar type or side mount (jack shaft) type as recommended by the manufacturer. Include operators with electric motor, machine-cut reduction gears, steel chain and sprockets, magnetic brake, brackets, pushbutton controls, limit switches, magnetic reversing contactor, a manual chain hoist operator for emergency use, and other accessories necessary for operation. Design electric operator so motor may be removed without disturbing the limit switch timing and without affecting the manual operator. Provide the operator with slipping clutch coupling to prevent stalling the motor. Provide a clutch controlled emergency manual operator so that it may be engaged and disengaged from the floor; do not affect limit switch timing by operation. The manual operator is not required if door can be manual-pushup operated with a force not to exceed 11.25 kilograms (25 pounds). Provide an electrical or mechanical device that disconnects the motor from the operating mechanism when the manual operator is engaged.

2.6.2 Motors

NEMA MG 1, high-starting torque, reversible type with sufficient horsepower and torque output to move the door in either direction from any position. Provide a motor to produce a door travel speed of not less than 200 mm (8 inch) or more than 300 mm (one foot) per second without exceeding the rated capacity. Motors shall operate on characteristics indicated at not more than 377 rad/s (3600 rpm). Single-phase motors shall not have commutation or more than one starting contact. Provide motor enclosures with drip-proof type or NEMA TENV type.

2.6.3 Controls

Provide a motor for each door with an enclosed, across-the-line type, magnetic reversing contactor, thermal overload and undervoltage protection, solenoid-operated brake, limit switches, and control switches. Locate control switches at least 1500 mm (5 feet) above the floor so the operator will have complete visibility of the door at all times. Provide control equipment to conform to NEMA ICS 1 and NEMA ICS 2. Provide control enclosures with NEMA ICS 6, Type 12 or Type 4, except that contactor enclosures may be Type 1. Provide a three-button type control switch stations with buttons marked "OPEN," "CLOSE," and "STOP." The "OPEN" and "STOP" buttons shall require only momentary pressure to operate. The "CLOSE" button shall require constant pressure to maintain the closing motion of the door. If the door is in motion and the "STOP" button is pressed or the "CLOSE" button released, the door shall stop instantly and remain in the stop position; from the stop position, the door may be operated in either direction by the "OPEN" or "CLOSE" button. Pushbuttons shall be full-guarded to prevent accidental operation. Provide limit switches to automatically stop doors at the fully open and closed positions. Limit switch positions shall be readily adjustable.

2.6.4 Safety Device

Provide entrapment protection safety device on the bottom edge of electrically-operated doors in accordance with UL 325. The device shall immediately stop and reverse the door movement during the closing travel upon contact with an obstruction in the door opening or upon failure of any device or component of the control system. Provide for an automatic lock-out on the door closing circuit and provide a manually operable door until the failure or damage has been corrected. No entrapment protection device shall be used as a limit switch, unless its function is specifically intended to do so.

2.6.5 Control Transformers

NEMA ST 20. Provide transformers in power circuits as necessary to reduce the voltage on the control circuits to 120 volts or less.

2.6.6 Electrical Components

NFPA 70. Furnish manual or automatic control and safety devices, including extra flexible Type SO cable and spring-loaded automatic take-up reel or equivalent device, for operation of the doors. Conduit wiring and mounting of controls are specified in the corresponding electrical specification section.

2.6.7 Hazardous Locations

Conform to NFPA 70 In addition to meeting other requirements specified, electrical materials, equipment, and devices for installation in hazardous locations and be specifically approved by Underwriters Laboratories or by an independent testing agency using equivalent standards, for the particular chemical group and the class and division of hazardous location involved.

2.7 WEATHER SEALS AND SAFETY DEVICE

Provide exterior doors with weatherproof joints between sections by means of tongue-and-groove joints, rabbet joints, shiplap joints, or wool pile, vinyl or rubber weather-stripping; a rubber, or vinyl adjustable weather-strip at the top and jambs; and a compressible neoprene or rubber weather seal attached to the bottom of the door. On exterior doors that are electrically operated, where a sensing edge is employed, the bottom seal shall be combination compressible weather seal and safety device for stopping and reversing door movement.On interior doors that are electrically operated , where a sensing edge is employed, the bottom seal shall be a compressible type of safety device for stopping and reversing door movement.

2.8 FINISHES

Hot-dip galvanize concealed metal surfaces and tracks in accordance with ASTM A123/A123M. Hot-dip galvanized and other ferrous metal surfaces, except rollers and lock components, which are galvanized or plated shop primed.

2.8.1 Galvanized and Shop Primed

Provide a zinc coating on specified surfaces, a phosphate treatment, and a shop prime coat of rust-inhibitive paint. Conform to ASTM A653/A653M for galvanized coating, coating designation Z180 (G60), for steel sheets, and ASTM A123/A123M for assembled steel products. The weight of coatings for assembled products shall be as designated in Table I of ASTM A123/A123M for the class of material to be coated. Provide a prime coat especially developed for materials treated by phosphates and adapted to application by dipping or spraying. Repair damaged zinc-coated surfaces with galvanizing repair paint and spot prime. At the Contractor's option, a two-part system including bonder, baked-on epoxy primer, and baked-on enamel topcoat may be applied in lieu of prime coat specified.

2.8.2 Aluminum

Provide a clear anodized finish to aluminum surfaces in accordance with AA-M10-C22-A41 contained in AA DAF45 and NAAMM AMP 500. Pre-treat exposed surfaces and apply a white baked-on enamel finish in accordance with manufacturer's standard.

PART 3 EXECUTION

3.1 INSTALLATION

NFPA 70. Install doors in accordance with approved shop drawings and manufacturer's written installation instructions. Lubricate and adjust doors to operate freely.

Provide a weathertight installation and free from warp, twist, or distortion. Adjust and lubricate doors to operate freely.

Provide all items and accessories for a complete installation in every respect.

3.2 ELECTRICAL WORK

NFPA 70. Conduit, wiring, and mounting of controls.

3.3 TESTING

After installation is complete, operate doors to demonstrate installation and function of operators, safety features, and controls. Correct deficiencies.

3.4 OPERATION AND MAINTENANCE

Submit Data Package 2 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

-- End of Section --

SECTION 08 51 13

ALUMINUM WINDOWS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 1302.5	(1976) Voluntary Specifications for Forced-Entry Resistant Aluminum Prime Windows
AAMA 1503	(2009) Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections
AAMA 2603	(2002) Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels
AAMA 2604	(2005) Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels
AAMA 2605	(2005) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels
AAMA 611	(1998; R 2004) Voluntary Specification for Anodized Architectural Aluminum
AAMA 701/702	(2004) Voluntary Specification for Pile Weatherstripping and Replaceable Fenestration Weatherseals
AAMA 902	(1992; R 1999; R 2007) Voluntary Specification for Sash Balances
AAMA WSG.1	(1995) Window Selection Guide
AAMA/WDMA/CSA 101/I.S.2/A440	(2011) Standard/Specification for Windows, Doors, and Skylights

ASTM INTERNATIONAL (ASTM)

ASTM A276	(2010) Standard Specification for Stainless Steel Bars and Shapes
ASTM E1300	(2009a) Determining Load Resistance of Glass in Buildings
ASTM F1642	(2004; R 2010) Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
ASTM F2248	(2009) Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass

GREEN SEAL (GS)

GS-36	(2011; R 2013) Green Seal Standard for Commercial Adhesives

INTERNATIONAL WINDOW CLEANING ASSOCIATION (IWCA)

IWCA I-14.1	(2001) Window Cleaning Safety Standard

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 8303	(2009) Combined coatings of anodic oxide and organic coatings on aluminum and aluminum alloys

NATIONAL FENESTRATION RATING COUNCIL (NFRC)

NFRC 100	(2010) Procedure for Determining Fenestration Product U-Factors
NFRC 200	(2010) Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code

1.2 CERTIFICATION

Each prime window unit must bear the AAMA Label warranting that the product complies with AAMA/WDMA/CSA 101/I.S.2/A440. Certified test reports attesting that the prime window units meet the requirements of AAMA/WDMA/CSA 101/I.S.2/A440, including test size, will be acceptable in lieu of product labeling.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When

used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G
Fabrication Drawings

SD-03 Product Data

Windows
Hardware
Thermal-Barrier Windows
MullionsScreens
Weatherstripping
Accessories
Thermal Performance
Warranty

SD-05 Design Data

Structural Calculations For Deflection; G
Design Analysis; G

SD-06 Test Reports

Minimum condensation resistance factor
Resistance to forced entry
Standard Airblast Test; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

1.4.1 Shop Drawing Requirements

Submit Fabrication Drawings for aluminum window units showing complete window assembly including hardware, weather-stripping, and subframe assembly details.

Provide installation drawings that indicate elevations of windows, full-size sections, thickness and gages of metal, fastenings, proposed method of anchoring, size and spacing of anchors, details of construction, method of glazing, details of operating hardware, mullion details, method and materials for weather-stripping, method of attaching screens, material and method of attaching subframes, stools, casings, sills, trim, window cleaner anchors, installation details, and other related items.

1.4.2 Design Data Requirements

Submit calculations to substantiate compliance with deflection requirements and Minimum Antiterrorism Performance criteria. A registered Professional Engineer must provide calculations.

Submit design analysis with calculations showing that the design of each different size and type of aluminum window unit and its anchorage to the structure meets the requirements of paragraph "Minimum Antiterrorism Performance Criteria". Calculations verifying the structural performance of each window proposed for use, under the given loads, must be prepared and signed by a registered professional engineer. Reflect the window components and anchorage devices to the structure, as determined by the design analysis, in the shop drawings.

1.4.3 Test Report Requirements

Submit test reports for each type of window attesting that identical windows have been tested and meet the requirements specified herein for conformance to AAMA/WDMA/CSA 101/I.S.2/A440 including test size, and minimum condensation resistance factor (CRF), and resistance to forced entry, and, for Minimum Antiterrorism windows, in lieu of a Design Analysis, results of a Standard Airblast Test.

For Minimum Antiterrorism windows, in lieu of a Design Analysis, results of air-blast testing, whether by arena test or shock tube, shall be included in a test report, providing information in accordance with ASTM F1642, as prepared by the independent testing agency performing the test. The test results shall demonstrate the ability of each window proposed for use to withstand the air-blast loading parameters and achieve the hazard level rating specified in paragraph "Standard Air-blast Test Method".

1.5 DELIVERY AND STORAGE

Deliver windows to project site in an undamaged condition. Use care in handling and hoisting windows during transportation and at the jobsite. Store windows and components out of contact with the ground, under a weathertight covering, so as to prevent bending, warping, or otherwise damaging the windows. Repair damaged windows to an "as new" condition as approved. If windows cannot be repaired, provide a new unit.

1.6 PROTECTION

Protect finished surfaces during shipping and handling using the manufacturer's standard method. Do not apply coatings or lacquers to surfaces to which calking and glazing compounds must adhere.

1.7 FIELD MEASUREMENTS

Take field measurements prior to preparation of the drawings and fabrication.

1.8 PERFORMANCE REQUIREMENTS

1.8.1 Wind Loading Design Pressure

Design window components, including mullions, hardware, and anchors, to withstand a wind-loading design pressure of at least 1,400 pascal (30 pounds per square foot (psf)).

1.8.2 Tests

Test windows proposed for use in accordance with AAMA/WDMA/CSA 101/I.S.2/A440 for the particular type and quality window specified.

Perform tests by a nationally recognized independent testing laboratory equipped and capable of performing the required tests. Submit the results of the tests as certified laboratory reports required herein.

Minimum design load for a uniform-load structural test must be 2400 pascal 50 psf.

Test projected windows in accordance with the applicable portions of the AAMA WSG.1 for air infiltration, water resistance, uniform-load deflection, and uniform-load structural test.

Test double-hung windows in accordance with the applicable portions of the AAMA WSG.1 for air infiltration, water resistance, uniform-load deflection, and uniform-load structural test.1.9 WINDOW PERFORMANCE

Aluminum windows must meet the following performance requirements. Testing shall be performed by an independent testing laboratory or agency.

1.9.1 Structural Performance

Structural test pressures on window units must be for positive load (inward) and negative load (outward). After testing, there will be no glass breakage, permanent damage to fasteners, hardware parts, support arms or actuating mechanisms or any other damage which could cause window to be inoperable. There must be no permanent deformation of any main frame, sash or ventilator member in excess of the requirements established by AAMA/WDMA/CSA 101/I.S.2/A440 for the window types and classification specified in this section.

1.9.2 Minimum Antiterrorism Performance

Windows shall meet the minimum antiterrorism performance as specified in the paragraphs below. Conformance to the performance requirements shall be validated by one of the following methods.

1.9.2.1 Computational Design Analysis Method

Window frames, mullions, and sashes shall be designed to the criteria listed herein. Computational design analysis shall include calculations verifying the structural performance of each window proposed for use, under the given static equivalent loads.

Aluminum window framing members shall restrict deflections of the edges of glazing they support to L/60 under two times (2X) the glazing resistance per the requirements of ASTM F2248 and ASTM E1300. Glazing resistance shall be greater than equivalent 3-second duration loading per Window Schedule indicated on contact drawings. L denotes the length of the glazing supported edge. (L is to be based on edge length of glazing in frame and not on the distance between anchors that fasten frame to the structure.)

The glazing frame bite for the window frames shall be in accordance with ASTM F2248.

Window frames shall be anchored to the supporting structure with anchors designed to resist two times (2X) the glazing resistance in accordance with ASTM F2248 and ASTM E1300.

1.9.2.2 Alternate Dynamic Design Analysis Method

As an alternative to the static equivalent load design approach described above, window framing members, anchors, and glazing may be designed using a dynamic analysis to prove the window system will provide performance equivalent to or better than a very low hazard rating in accordance with ASTM F1642 associated with the applicable low level of protection for the project.

1.9.3 Air Infiltration

Air infiltration must not exceed the amount established by AAMA/WDMA/CSA 101/I.S.2/A440 for each window type.

1.9.4 Water Penetration

Water penetration must not exceed the amount established by AAMA/WDMA/CSA 101/I.S.2/A440 for each window type.

1.9.5 Thermal Performance

Non-residential aluminum windows (including frames and glass) shall be certified by the National Fenestration Rating Council with a whole-window maximum Solar Heat Gain Coefficient (SHGC) determined according to NFRC 200 procedures and a maximum U-factor in accordance with NFRC 100, as indicated on contract drawings

Residential aluminum windows (including frames and glass) shall be Energy Star qualified products as appropriate to Southern climate zone. To meet Energy Star criteria for the Southern climate one, thermal properties of windows must not exceed a U-factor of 3.4 W/m^2K 0.60 $Btu/hr\text{-}ft^2\text{-}F$ determined according to NFRC 100, and a solar heat gain coefficient (SHGC) of 0.27 determined according to NFRC 200.

1.9.6 Life Safety Criteria

Provide windows that conform to NFPA 101 Life Safety Code when rescue and/or second means of escape are indicated.

1.10 QUALIFICATION

Window manufacturer must specialize in designing and manufacturing the type of aluminum window specified in this section, and have a minimum of 5 years of documented successful experience. Manufacturer must have the facilities capable of meeting contract requirements, single-source responsibility and warranty.

1.11 WARRANTY

Provide Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period.

PART 2 PRODUCTS

2.1 WINDOWS

Provide prime windows that comply with AAMA/WDMA/CSA 101/I.S.2/A440 and the requirements specified herein. In addition to compliance with AAMA/WDMA/CSA 101/I.S.2/A440, window framing members for each individual light of glass must not deflect to the extent that deflection perpendicular to the glass light exceeds L/175 of the glass edge length when subjected to uniform loads at specified design pressures. Provide Structural calculations for deflection to substantiate compliance with deflection requirements. Provide windows of types, performance classes, performance grades, combinations, and sizes indicated or specified. Design windows to accommodate hardware, glass, weather-stripping, screens, and accessories to be furnished. Each window must be a complete factory assembled unit with or without glass installed. Dimensions shown are minimum dimensions. Provide windows with insulating glass and thermal break necessary to achieve a minimum Condensation Resistance Factor (CRF) of 48 when tested in accordance with AAMA 1503.

2.1.1 Awning Windows (AP)

Type AP-R15, LC25, CW30, or AW40, as indicated. Conceal operating mechanism within the frame members or enclose within a metal casing not less than 1.59 mm (0.0625 inch) thick sheet aluminum.

2.1.2 Casement Windows (C)

Type C-R15, LC25, CW30, or AW40, as indicated. Ventilators must be rotary crank or handle operated. Provide ventilators over 1650 millimeters (65 inches) high with two separate locking devices or a two-point locking device operated by rods from a single lever handle. Conceal rods where possible.

2.1.3 Hung Windows (H)

Double Hung, Type H-R15, LC25, CW30, or AW40, as indicated. Test and rate sash balance to conform with AAMA 902.

Design windows, mullions, hardware, and anchors to withstand the wind loading specified.

2.1.3.1 Window Materials

Window frames and sash members, mullions, mullion covers, screen frames, and glazing beads shall be fabricated in accordance with AAMA/WDMA/CSA 101/I.S.2/A440.

Weather-stripping will be woven wool pile weather-stripping 5.3 millimeter (0.210 inch) thick, conforming to AAMA 701/702, or polypropylene multifilament fiber weather-stripping installed in an integral weather-stripping groove in the sash or frame, and flexible polyvinylchloride weather-stripping installed in the sill member.

2.1.4 Horizontal Sliding Windows (HS)

Type HS-R15, LC25, CW30, or AW40, as indicated.

2.1.5 Projected Windows (AP)

Type AP-R15, LC25, CW30, or AW40, as indicated. Provide projected windows with concealed four bar friction hinges only.

2.1.6 Top-Hinged Windows (TH)

Type TH-CW30, or AW40, as indicated. Top-hinged windows must be in swinging or out swinging.

2.1.7 Vertically Pivoted Windows (VP)

Type VP-R15, LC25, CW30, or AW40, as indicated.

2.1.8 Fixed Windows (F)

Type F-R15, LC25, CW30, or AW40, as indicated.

2.1.9 Forced Entry Resistant Windows

In addition to meeting the requirements of AAMA/WDMA/CSA 101/I.S.2/A440, windows designated for resistance to forced entry must conform to the requirements of AAMA 1302.5.

2.1.10 Glass and Glazing

Materials are specified in Section 08 81 00 GLAZING.

2.1.11 Calking and Sealing

Are specified in Section 07 92 00 JOINT SEALANTS.

2.1.12 Weather-stripping

AAMA/WDMA/CSA 101/I.S.2/A440.

2.1.13 Sash Poles

Seamless aluminum tube, 1.59 mm (0.0625 inch) minimum wall thickness, 25 mm (one inch) diameter, with cast aluminum hook and protective cover or tip on the lower end. Finish must match windows.

2.2 FABRICATION

Fabrication of window units must comply with AAMA/WDMA/CSA 101/I.S.2/A440.

2.2.1 Provisions for Glazing

Design windows and rabbets suitable for glass thickness shown or specified. For minimum antiterrorism windows, attach glazing to its supporting frame using structural silicone sealant or adhesive glazing tape in accordance with ASTM F2248. Design sash for inside glazing unless otherwise indicated and for securing glass with metal beads, glazing clips, glazing channels, or glazing compound.

2.2.2 Weather-stripping

Provide for ventilating sections of all windows to ensure a weather-tight seal meeting the infiltration requirements specified in AAMA/WDMA/CSA 101/I.S.2/A440. Provide easily replaceable factory-applied weather-stripping. Use molded vinyl, molded or molded-expanded neoprene or molded or expanded Ethylene Propylene Diene Terpolymer (EPDM) compression-type weather-stripping for compression contact surfaces. Use treated woven pile or wool, or polypropylene or nylon pile bonded to nylon fabric and metal or plastic backing strip weather-stripping for sliding surfaces. Do not use neoprene or polyvinylchloride weather-stripping where they will be exposed to direct sunlight.

2.2.3 Fasteners

Fabricated from 100 percent re-melted steel. Use fasteners as standard with the window manufacturer for windows, trim, and accessories. Self-tapping sheet-metal screws are not acceptable for material more than 2 mm (1/16 inch) thick.

2.2.4 Adhesives

Comply with applicable regulations regarding toxic and hazardous materials, GS-36, and as specified in Section 07 92 00 JOINT SEALANTS.

2.2.5 Drips and Weep Holes

Provide continuous drips over heads of top ventilators. Where fixed windows adjoin ventilators, drips must be continuous across tops of fixed windows. Provide drips and weep holes as required to return water to the outside.

2.2.6 Combination Windows

Windows used in combination must be the same class and grade and will be factory assembled. Where factory assembly of individual windows into larger units is limited by transportation considerations, prefabricate, match mark, transport, and field assemble.

2.2.7 Mullions and Transom Bars

Provide mullions between multiple window units to resist two times (2X) glazing resistance in accordance with ASTM F2248 and ASTM E1300. Provide mullions with a thermal break. Secure mullions and transom bars to adjoining construction and window units in such a manner as to permit expansion and contraction and to form a weathertight joint. Where window cleaner anchors are required, reinforce mullions and anchor to adjoining construction so as to provide safe and adequate support. Provide mullion covers on the interior and exterior to completely close exposed joints and recesses between window units and to present a neat appearance, when design requires. Provide special covers over structural support at mullions as indicated.

2.2.8 Accessories

Provide windows complete with necessary hardware, fastenings, clips, fins, anchors, glazing beads, and other appurtenances necessary for complete installation and proper operation.

2.2.8.1 Hardware

AAMA/WDMA/CSA 101/I.S.2/A440. The item, type, and functional characteristics must be the manufacturer's standard for the particular window type. Provide hardware of suitable design and of sufficient strength to perform the function for which it is used. Equip all operating ventilators with a lock or latching device which can be secured from the inside.

2.2.8.2 Fasteners

Provide concealed anchors of the type recommended by the window manufacturer for the specific type of construction. Anchors and fasteners must be compatible with the window and the adjoining construction. Provide a minimum of three anchors for each jamb located approximately 150 mm (6 inches) from each end and at midpoint.

2.2.8.3 Window-Cleaner Anchors

Provide double head anchors for windows indicated. Anchors must be stainless steel of size and design required for the window type and application, conforming to ASTM A276. Provide two anchors for each single window and each adjacent fixed glass window unit. Fasten anchors 1120 mm (44 inches) above the window sill utilizing appropriate methods for the window type and application in accordance with industry safety standards.

2.2.8.4 Window Anchors

Anchoring devices for installing windows must be made of aluminum, cadmium-plated steel, stainless steel, or zinc-plated steel conforming to AAMA/WDMA/CSA 101/I.S.2/A440.

2.2.9 Finishes

Exposed aluminum surfaces must be factory finished with an anodic coating or organic coating. Color must be as indicated. All windows will have the same finish.

2.2.9.1 Anodic Coating

Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF45 and AAMA 611 or KS D 8303. Finish must be:

a. Architectural Class II (0.01 to 0.0175 mm (0.4 mil to 0.7 mil)), designation AA-M10-C22-A31, clear (natural), A32, integral color, or A34, electrolytically deposited color anodized, or

b. Architectural Class I (0.0175 mm (0.7 mil) or thicker), designation AA-M10-C22-A41, clear (natural), A42, integral color, or A44, electrolytically deposited color anodized.

2.2.9.2 Organic Coating

Clean and prime exposed aluminum surfaces. Provide a baked enamel finish in accordance with AAMA 2603 with total dry film thickness not less than 0.02 mm (0.8 mil), or high-performance finish in accordance with AAMA 2604 or AAMA 2605 with total dry film thickness of not less than 0.03 mm (1.2 mils).

2.2.10 Screens

AAMA/WDMA/CSA 101/I.S.2/A440. Provide one insect screen for each operable exterior sash or ventilator. Design screens to be rewireable, easily removable from inside the building, and to permit easy access to operating hardware.

2.3 SPECIAL OPERATORS

For windows having operating hardware or locking or latching devices located more than 1800 mm (6 feet) above the floor, provide suitably designed operators or locking or latching devices necessary for convenient and proper window operation.

2.3.1 Pole Operators

Poles must be of proper length to permit window operation from 1500 mm (5 feet) above the floor. Provide one pole operator for each room, and one pole hanger for each pole. Locate hangers where directed.

2.3.2 Extension Crank Operators

Provide removable handles for crank-operated rotary-type operators located more than 1800 mm (6 feet) above the floor. Provide one removable handle for each room.

2.3.3 Mechanical Operators

Provide manual and/or electric motor driven as indicated on contract drawings, operators for group operation of continuous rows of windows located. Operators must be capable of opening and closing windows without appreciable deflection, vibration or rattle. Provide means of adjustment for transmission lines. Operators will control window units in groups as recommended by the window manufacturer or as indicated.

2.4 THERMAL-BARRIER WINDOWS

Provide thermal-barrier windows, complete with accessories and fittings, where indicated.

Specify material and construction except as follows:

a. Aluminum alloy must be 6063-T6.

b. Frame construction, including operable sash, must be factory-assembled and factory-sealed inner and outer aluminum completely separated from metal-to-metal contact. Join assembly by a continuous, concealed, low conductance divider housed in an interlocking extrusion of the inner frame. Metal fasteners, straps, or anchors will not bridge the connection between the inner and outer frame.

c. Operating hardware for each sash must consist of spring-loaded nylon cushion blocks and pin locks designed to lock in predetermined locations.

d. Sash must be completely separated from metal-to-metal contact by means of woven-pile weather-stripping, plastic, or elastomeric separation members.

e. Operating and storm sash will be factory-glazed with the type of glass indicated and of the quality specified in Section 08 81 00 GLAZING.

2.5 MULLIONS

Provide mullions between multiple-window units where indicated.

Mullions and mullion covers must be the profile indicated, reinforced as required for the specified wind loading, and securely anchored to the adjoining construction. Mullion extrusion will include serrations or pockets to receive weather-stripping, sealant, or tape at the point of contact with each window flange.

Mullion assembly must include aluminum window clamps or brackets screwed or bolted to the mullion and the mullion cover.

Mullion cover must be screw-fastened to the mullion unless otherwise indicated.

Mullion reinforcing members shall be fabricated of the materials specified in AAMA/WDMA/CSA 101/I.S.2/A440 and meet the specified design loading.

2.6 WINDOW CLEANERS' BOLTS

Provide window cleaners' bolts for all windows 2100 millimeter (7 feet) or higher above finished grade, except windows located so they may be removed for cleaning or cleaned from the ground or from a lower roof level without the use of an extension ladder. Provide two bolts for each single window unit and each fixed glass unit and must be located 1120 millimeter (44 inches) above the window sill.

Window cleaners' bolts must be double-head type, AISI Series 300 corrosion-resistant steel, size and design complying with IWCA I-14.1. Contact side of the bolts will be ground to fit flat against window jambs. Bolts may be factory- or field-attached before windows are set. Reinforce backs of frames to receive bolts with 6 by 150 millimeter (1/4 by 6-inch) corrosion-resistant steel or aluminum plates bolted or welded to the frames at the factory. Special wall anchors must be provided on frames at the point of bolt attachment.

2.7 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Metal Casing	0.0625 inch	1.59 mm
Aluminum Tube (Diameter)	0.0625 inch	1.59 mm
	1 inch	25 mm

3.2 INSTALLATION

3.2.1 Method of Installation

Install in accordance with the window manufacturer's printed instructions and details. Build in windows as the work progresses or install without forcing into prepared window openings. Set windows at proper elevation, location, and reveal; plumb, square, level, and in alignment; and brace, strut, and stay properly to prevent distortion and misalignment. Protect ventilators and operating parts against accumulation of dirt and building materials by keeping ventilators tightly closed and locked to frame. Bed screws or bolts in sill members, joints at mullions, contacts of windows with sills, built-in fins, and subframes in mastic sealant of a type recommended by the window manufacturer. Install and caulk windows in a manner that will prevent entrance of water and wind. Fasten insect screens securely in place.

3.2.2 Dissimilar Materials

Where aluminum surfaces are in contact with, or fastened to masonry, concrete, wood, or dissimilar metals, except stainless steel or zinc, protect the aluminum surface from dissimilar materials as recommended in the Appendix to AAMA/WDMA/CSA 101/I.S.2/A440. Do not coat surfaces in contact with sealants after installation with any type of protective material.

3.2.3 Anchors and Fastenings

Make provision for securing units to each other, to masonry, and to other adjoining construction. Windows installed in masonry walls must have head and jamb members designed to recess into masonry wall not less than 11 mm (7/16 inch).

3.2.4 Adjustments After Installation

After installation of windows and completion of glazing and field painting, adjust all ventilators and hardware to operate smoothly and to provide weathertight sealing when ventilators are closed and locked. Lubricate hardware and operating parts as necessary. Adjust double hung windows to operate with maximum applied force of 25 pounds in either direction, not including breakaway friction force. Verify that products are properly installed, connected, and adjusted.

3.3 CLEANING

Clean interior and exterior surfaces of window units of mortar, plaster, paint spattering spots, and other foreign matter to present a neat appearance, to prevent fouling of weathering surfaces and weather-stripping, and to prevent interference with the operation of hardware. Replace all stained, discolored, or abraded windows that cannot be restored to their original condition with new windows.

3.4 WASTE MANAGEMENT

Separate corrugated cardboard and protective materials in accordance with the Waste Management Plan and place in designated areas for reuse or recycling. Place materials defined as hazardous or toxic waste in designated containers. Close and seal tightly all partly used sealant containers and store protected in well ventilated fire-safe area at moderate temperature. Place used sealant tubes and containers in areas designated for hazardous materials.

3.5 OPERATION AND MAINTENANCE MANUALS

Submit Data Package 1 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

-- End of Section --

SECTION 08 52 00

WOOD WINDOWS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2603	(2002) Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels
AAMA 2604	(2005) Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels
AAMA/WDMA/CSA 101/I.S.2/A440	(2011) Standard/Specification for Windows, Doors, and Skylights

ASTM INTERNATIONAL (ASTM)

ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D3656	(2007) Insect Screening and Louver Cloth Woven from Vinyl-Coated Glass Yarns
ASTM D6007	(2002; R 2008) Standard Test Method for Determining Formaldehyde Concentration in Air from Wood Products Using a Small Scale Chamber
ASTM D6330	(1998; R 2008) Standard Practice for Determination of Volatile Organic Compounds (Excluding Formaldehyde) Emissions from Wood-Based Panels Using Small Environmental Chambers Under Defined Test Conditions
ASTM E1333	(2010) Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber

GREEN SEAL (GS)

GS-36	(2011; R 2013) Green Seal Standard for Commercial Adhesives

SCREEN MANUFACTURERS ASSOCIATION (SMA)

SMA 1004	(1987; R 1998) Aluminum Tubular Frame Screens for Windows

WINDOW AND DOOR MANUFACTURERS ASSOCIATION (WDMA)

WDMA I.S. 4	(2009) Water-Repellent Preservative Non-Pressure Treatment for Millwork

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Engineered Wood Products
Wood windows

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 SHOP DRAWINGS

Submit installation drawings indicating elevations of units, full-size sections, fastenings, methods of installation and anchorage, method of glazing, locations of operating hardware, mullion details, method and material for weather-stripping, bar and muntin layouts, method of attaching insect screens, details of installation, and connections with other work.

1.4 DELIVERY AND STORAGE

Deliver windows to site in sealed undamaged cartons or in palletized multiple units. Protect from damage, dampness and extreme temperature or humidity changes. Store under cover in well-ventilated enclosed space. Do not store in a building under construction until concrete, masonry, and plaster are dry. Replace defective or damaged windows.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Engineered Wood Products

Products shall contain no added urea-formaldehyde. Determine formaldehyde concentrations in air from engineered wood products under test conditions of temperature and relative humidity in accordance with ASTM D6007 or ASTM E1333. Products shall not be used if formaldehyde concentration is found to be greater than 0. Determine Volatile Organic Compounds (VOCs), excluding formaldehyde, emitted from manufactured wood-based panels in accordance with ASTM D6330. Products shall not be used if VOC emissions exceed 0. Products shall be FSC-certified.

2.2 WOOD WINDOWS

Wood windows shall consist of complete units including sash, glass, frame, weather-stripping, insect screen, and hardware. Window units shall meet the Grade 40 requirements of AAMA/WDMA/CSA 101/I.S.2/A440, except maximum air infiltration shall not exceed 0.00016 cu m per second (0.34 CFM per linear foot) of sash crack when tested under uniform static air pressure difference of 75 pascals (1.57 psf). In addition to general hardware requirements of AAMA/WDMA/CSA 101/I.S.2/A440, provide hardware for various window types as indicated below. Glass and glazing materials shall conform to Section 08 81 00 GLAZING. Wood members which will receive transparent finish shall be in one piece, not finger-jointed.

2.2.1 Single-Hung and Double-Hung Windows

Provide with one sash fastener and two sash lifts, except provide one sash lift when window is fitted with a balance that counterbalances weight of sash.

2.2.2 Awning Windows (Top Hinged)

Awning window ventilators in same bay shall operate in unison. Provide two or more hinges, pivots, or sash-supporting arms for each operative sash to allow easy operation, substantial support and cleaning of both sides of sash from inside. Provide latches for securing each sash if operating devices do not include locking features. Provide operating devices for controlling position of sash, including full open, tight close, and intermediate firm hold. Operating devices shall include rotary operators of worm-gear type with wear-resistant and impact-resistant gears or lever operators of lever handle, off-set arm type. Venting sash shall have corrosion resistant steel hinges connected to top and bottom rails of sash. When lever operators are used, operating arms shall be adjustable so that even sash edge contact can be maintained.

2.2.3 Casement Windows

Provide two or more hinges, pivots, or sash-supporting arms for each operative sash to allow easy operation, substantial support and cleaning of both sides of sash from inside. Provide latches for securing each sash if operating devices do not include locking features. Provide operating devices for controlling the position of the operative sash, including full open, tight close, and intermediate firm hold. Operating devices shall include rotary gears and adjustable operating arms so that even sash contact can be maintained.

2.2.4 Horizontal-Sliding Windows

Provide latches, pulls, and corrosion resistant steel slides necessary to control and secure window. Provide for cleaning of both sides of sash from inside.

2.2.5 Stationary Windows

Provide fixed sash and basic frame in accordance with AAMA/WDMA/CSA 101/I.S.2/A440.

2.3 ACCESSORIES

2.3.1 Adhesives

Comply with applicable regulations regarding toxic and hazardous materials, GS-36, and as specified in Section 07 92 00 JOINT SEALANTS.

2.4 FINISHES

2.4.1 Paint

Furnish windows with factory-primed surfaces which will be exempt from first paint coat application required in Section 09 90 00 PAINTS AND COATINGS.

2.4.2 Vinyl (PVC) Cladding

Preservative treat all basic wood frame and sash members in accordance with WDMA I.S. 4 and Section 06 10 00 ROUGH CARPENTRY, except do not use pentachlorophenol. Clad all exterior surfaces with rigid polyvinyl sheathing, complying with ASTM D1784, class 14344-C, not less than 0.9 mm (35 mil) average thickness.

2.4.3 Aluminum Cladding

Preservative treat all basic wood frame and sash members in accordance with WDMA I.S. 4, except do not use pentachlorophenol. Clad all exterior surfaces with roll formed aluminum with joints sealed during assembly. Aluminum clad frames and sash shall meet performance requirements of AAMA/WDMA/CSA 101/I.S.2/A440.

2.4.3.1 Aluminum Finish

Factory finish with anodic coating or organic coating.

2.4.3.2 Anodic Coating

Conform to AA DAF45. Finish shall be clear (natural), designation AA-M10-C22-A31, Architectural Class II 0.010 to 0.0175 mm (0.4 mil to 0.7 mil), or clear (natural), designation AA-M10-C22-A41, Architectural Class I 0.0175 mm (0.7 mil) or thicker, unless otherwise indicated.

2.4.3.3 Organic Coating

Clean and prime exposed aluminum surfaces. Provide baked enamel finish in accordance with AAMA 2603 with total dry film thickness not less than 0.020 mm (0.8 mil), or high performance finish in accordance with AAMA 2604 with total dry film thickness of not less than 0.030 mm (1.2 mils). Finish color as indicated.

2.5 INSECT SCREENS

ASTM D3656, Class 2, 18 by 14 mesh, color grey. Aluminum frames to meet SMA 1004.

2.6 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Wood and Wood Clad Windows

Install in accordance with the approved installation instructions. Securely anchor windows in place. Install and seal windows in a manner that will prevent entrance of water and wind.

3.1.2 Insect Screen

Install screen panels in accord with manufacturer's instructions. Install aluminum framed screens in accord with SMA 1004.

3.2 ADJUSTMENTS

Make final adjustment for proper operation of ventilating unit after glazing. Make adjustments to operating sash or ventilators to assure smooth operation. Units shall be weathertight when locked closed. Verify products are properly installed, connected, and adjusted.

3.3 CLEANING

Clean windows on both exterior and interior in accordance with manufacturer's recommendations.

3.4 WASTE MANAGEMENT

Separate corrugated cardboard and protective materials in accordance with the Waste Management Plan and reuse or recycle. Place materials defined as hazardous or toxic waste in designated containers and dispose of properly. Close and seal tightly all partly used sealant containers and store protected in well ventilated fire-safe area at moderate temperature. Place used sealant tubes and containers in areas designated for hazardous materials and dispose of properly.

3.5 OPERATION AND MAINTENANCE MANUALS

Submit Data Package 1 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

-- End of Section --

SECTION 08 71 00

DOOR HARDWARE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM E283	(2004) Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM F883	(2009) Padlocks

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.1	(2006) Butts and Hinges
ANSI/BHMA A156.13	(2005) Mortise Locks & Latches Series 1000
ANSI/BHMA A156.15	(2006) Release Devices Closer Holder, Electromagnetic and Electromechanical
ANSI/BHMA A156.16	(2008) Auxiliary Hardware
ANSI/BHMA A156.17	(2004; R 2010) Self Closing Hinges & Pivots
ANSI/BHMA A156.18	(2006) Materials and Finishes
ANSI/BHMA A156.2	(2011) Bored and Preassembled Locks and Latches
ANSI/BHMA A156.21	(2009) Thresholds
ANSI/BHMA A156.22	(2005) Door Gasketing and Edge Seal Systems
ANSI/BHMA A156.23	(2010) Electromagnetic Locks
ANSI/BHMA A156.3	(2008) Exit Devices
ANSI/BHMA A156.4	(2008) Door Controls - Closers
ANSI/BHMA A156.5	(2010) Auxiliary Locks and Associated Products
ANSI/BHMA A156.6	(2010) Architectural Door Trim
ANSI/BHMA A156.7	(2003; R 2009) Template Hinge Dimensions

ANSI/BHMA A156.8 (2010) Door Controls - Overhead Stops and Holders

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4505 (2000) Door Closers

KS F 4525 (2007) Fittings for Steel Door

KS F 4533 (2008) Pivot Hinge

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101 (2015) Life Safety Code

NFPA 80 (2013) Standard for Fire Doors and Other Opening Protectives

STEEL DOOR INSTITUTE (SDI/DOOR)

SDI/DOOR A250.8 (2003; R2008) Recommended Specifications for Standard Steel Doors and Frames

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir (2012) Building Materials Directory

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

SD-02 Shop Drawings

Hardware schedule
Keying system

SD-03 Product Data

Hardware items; G

1.3 HARDWARE SCHEDULE

Prepare and submit hardware schedule in the following form:

Hardware Item	Quantity	Size	Reference Publi-cation Type No.	Finish	Mfr Name and Catalog No.	Key Control Symbols	UL Mark (If fire rated and listed)	BHMA Finish Desig-nation

1.4 KEY BITTING CHART REQUIREMENTS

Submit key bitting charts to the Contracting Officer prior to completion of the work. Include:

a. Complete listing of all keys (AA1, AA2, etc.).

b. Complete listing of all key cuts (AA1-123456, AA2-123458).

c. Tabulation showing which key fits which door.

d. Copy of floor plan showing doors and door numbers.

e. Listing of 20 percent more key cuts than are presently required in each master system.

1.5 QUALITY ASSURANCE

1.5.1 Hardware Manufacturers and Modifications

Provide, as far as feasible, locks, hinges, pivots, and closers of one lock, hinge, pivot, or closer manufacturer's make. Modify hardware as necessary to provide features indicated or specified.

1.5.2 Key Shop Drawings Coordination Meeting

Prior to the submission of the key shop drawing, the Contracting Officer, Contractor, Door Hardware subcontractor, using Activity and Base Locksmith shall meet to discuss key requirements for the facility.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver hardware in original individual containers, complete with necessary appurtenances including fasteners and instructions. Mark each individual container with item number as shown in hardware schedule. Deliver permanent keys and removable cores to the Contracting Officer, either directly or by certified mail. Deliver construction master keys with the locks.

PART 2 PRODUCTS

2.1 TEMPLATE HARDWARE

Provide hardware to be applied to metal or to prefinished doors manufactured to template. Promptly furnish template information or templates to door and frame manufacturers. Conform to ANSI/BHMA A156.7 for template hinges. Coordinate hardware items to prevent interference with other hardware.

2.2 HARDWARE FOR FIRE DOORS AND EXIT DOORS

Provide all hardware necessary to meet the requirements of NFPA 80 for fire doors and NFPA 101 for exit doors, as well as to other requirements indicated, even if such hardware is not specifically mentioned under paragraph entitled "Hardware Schedule." Provide the label of Underwriters Laboratories, Inc. for such hardware listed in UL Bld Mat Dir or labeled and listed by another testing laboratory acceptable to the Contracting Officer.

2.3 HARDWARE ITEMS

Clearly and permanently mark with the manufacturer's name or trademark, hinges, pivots, locks, latches, exit devices, bolts and closers where the identifying mark will be visible after the item is installed. For closers with covers, the name or trademark may be beneath the cover.

2.3.1 Hinges

ANSI/BHMA A156.1, 114 by 114 mm (4-1/2 by 4-1/2 inch) unless otherwise indicated. Construct loose pin hinges for exterior doors and reverse-bevel interior doors so that pins will be non-removable when door is closed. Other antifriction bearing hinges may be provided in lieu of ball-bearing hinges.

2.3.2 Pivots

ANSI/BHMA A156.4 or KS F 4533.

2.3.3 Spring Hinges

ANSI/BHMA A156.17.

2.3.4 Locks and Latches

2.3.4.1 Mortise Locks and Latches

ANSI/BHMA A156.13, Series 1000, Operational Grade 1, Security Grade 2. Install knobs and roses of mortise locks with screwless shanks and no exposed screws.

2.3.4.2 Bored Locks and Latches

ANSI/BHMA A156.2, Series 4000, Grade 1.

2.3.4.3 Residential Bored Locks and Latches

ANSI/BHMA A156.2, Series 4000, Grade 2. Install locks for exterior doors with threaded roses or concealed machine screws.

2.3.4.4 Hospital Latches

Push-pull latch set similar and equal to Glynn-Johnson HL6, 13 mm (1/2 inch) throw, 127 mm (5 inch) backset, to fit 161 cutout. Cover approximately 64 by 140 mm (2-1/2 by 5-1/2 inch), handle approximately 38 by 114 mm (1-1/2 by 4-1/2 inch), projection approximately 64 mm (2-1/2 inch), covers and handles of stainless steel, BHMA 630 finish, engraved "PUSH" and "PULL" on handles, push handle pointing up, pull handle pointing down.

2.3.4.5 Auxiliary Locks

ANSI/BHMA A156.5, Grade 1.

2.3.4.6 Combination Locks

Heavy-duty, mechanical combination lockset with five pushbuttons, standard-sized knobs, 20 mm (3/4 inch) deadlocking latch, 70 mm (2-3/4 inch) backset. Operate the locks by pressing two or more of the buttons in unison or individually in the proper sequence. Inside knob will operate the latch. Provide a keyed cylinder on the interior to permit setting the combination.

2.3.4.7 Electro-Mechanical Locks

Electro-mechanical locks shall allow for locking or unlocking of doors from a remote location by means of push buttons or card reader. Locks shall be fail safe mode (unlocked when power is off). Locks shall be manufactured electro-mechanical locks conforming to ANSI/BHMA A156.13 or ANSI/BHMA A156.2 test standards. In hazardous locations, products shall use safe power supplies or be pneumatic.

2.3.5 Exit Devices

ANSI/BHMA A156.3, Grade 1. Provide adjustable strikes for rim type and vertical rod devices. Provide open back strikes for pairs of doors with mortise and vertical rod devices. Provide touch bars in lieu of conventional crossbars and arms. Provide escutcheons, not less than 178 by 57 mm (7 by 2-1/4 inch).

2.3.6 Exit Locks With Alarm

ANSI/BHMA A156.5, Type E0431 (with full-width horizontal actuating bar) for single doors; Type E0431 (with actuating bar) or E0471 (with actuating bar and top and bottom bolts, both leaves active) for pairs of doors, unless otherwise specified.

2.3.7 Cylinders and Cores

2.3.7.1 Conventional

Provide cylinders and cores for new locks, including locks provided under other sections of this specification. Provide cylinders and cores with seven pin tumblers. Provide cylinders from products of one manufacturer, and provide cores from the products of one manufacturer. Rim cylinders, mortise cylinders, and knobs of bored locksets have interchangeable cores which are removable by special control keys. Stamp each interchangeable core with a key control symbol in a concealed place on the core.

2.3.7.2 Mechanical Coded

Lock cylinder shall have not less than 35 magnetic pins, each pin having a North and South Pole. Each cylinder shall have anti-rap magnets on the opposite sides of the core. Pins shall operate mechanically without the use of electrical power. Lock cylinders shall have a construction code setting for use during construction and shall be capable of being reset from outside of the locked room after construction is completed. Lock cylinders shall be changeable on-site without removal or disassembly of the cylinder. Each cylinder shall be capable of accepting a minimum of 16 different code changes as sub-codes to the basic cylinder.

2.3.7.3 Electronic Card Keyed Lock

Lock shall be all-metals, heavy-duty electronic mortise and cylindrical lockset with one-inch solid metal deadbolt. Lock shall be ADA compliant and have a two-year warranty. Provide mechanical key override with removable core or electronic override as a standard. Lock shall operate with four AA standard alkaline batteries, have all electronics and batteries located inside housing and have stand-alone function with no wiring requirement. Lock shall have magnetic stripe key-card reader with open reader slot in vertical swipe position and low battery indicator. Lock shall be capable to be operated using a CAC ID card. Interior locks shall have classic satin chrome plated finish. Exterior locks shall have ultra-plated finish. At exterior fire doors equipped with panic device provide electronic key-card exit device operator conversion kit.

2.3.7.4 Electromagnetic Locks

Electromagnetic locks shall allow for locking or unlocking of doors from a remote location by means of push buttons or card reader. Electromagnetic locks shall be fail safe (unlocked when power is off) and shall conform to ANSI/BHMA A156.23.

2.3.8 Keying System

Provide a master keying system.

2.3.8.1 Conventional

Locks shall be keyed in sets or subsets as scheduled. Locks shall be furnished with the manufacturer's standard construction key system. Change keys for locks shall be stamped with change number and the inscription "U.S. Property - Do Not Duplicate." Keys shall be supplied as follows:

Locks: 3 change keys each lock.
Master keyed sets: 3 keys each set.
Grand master keys: 3 total.
Control key: 2 ea
Construction key: As required.
Blank keys: 50% of total change keys.

The keys shall be turned over to the Contracting Officer properly tagged and designated as to location, and arranged in a container in sets or subsets as scheduled. For buildings where locksets are to be replaced partially with new ones for repair and upgrading, supply of master keyed sets and grand master keyed sets shall not be required unless otherwise indicated. Key cabinets shall be provided for each master key system or each grand master key system.

2.3.8.2 Mechanical Coded

Keys shall be fabricated of stainless steel with magnetic insert and keying hole reinforced with an eyelet. Key size shall be approximately 1-1/2 by 2-3/4 inches with radius top and bottom edges, approximately 0.05 inches thick. The correct position for key insertion to be marked on the key with an arrow. Keys shall be capable of accepting coding for unlocking and locking the cylinders provided. Master keys shall be capable of being encoded to operate multiple cylinders in a master keying security system. Keys shall be capable of being erased and recoded as often as desired. Key codes shall be invisible. Keys shall be obtainable in bulk, uncoded, or precoded for on-site additional encoding or they may be factory-coded. Identification of keys shall be by serial number. Stainless steel keys to be guaranteed recodeable for 10 years. The entire cylinder system shall be capable of being re-mastered, including the highest master up to 15 times by the user and including on-site recoding of existing valid keys to the new combination. Initial coding shall be by the supplier. Each differently coded cylinder shall be supplied with 1 working key. Also, 2 master keys for each occupant and 3 for each building master shall be provided. Spare steel keys shall be pre-coded for on-site additional encoding. Blank keys equal to 20% of total occupants shall be provided.

2.3.8.3 Electronic Card Keying

Electronic card keying system shall include portable front desk unit (FDU) or approved equal by the Contracting Officer. Provide 10 percent of total electronic key-cards in extra stock.

2.3.9 Lock Trim

Cast, forged, or heavy wrought construction and commercial plain design.

2.3.9.1 Knobs and Roses

Conform to the minimum test requirements of ANSI/BHMA A156.2 and ANSI/BHMA A156.13 for knobs, roses, and escutcheons. For unreinforced knobs, roses, and escutcheons, provide 1.25 mm (0.050 inch) thickness. For reinforced knobs, roses, and escutcheons, provide outer shell of 0.89 mm (0.035 inch) thickness, and combined thickness of 1.78 mm (0.070 inch), except for knob shanks, which are 1.52 mm (0.060 inch) thick.

2.3.9.2 Lever Handles

Provide lever handles in lieu of knobs where indicated. Conform to the minimum requirements of ANSI/BHMA A156.13 for mortise locks of lever handles for exit devices. Provide lever handle locks with a breakaway feature (such as a weakened spindle or a shear key) to prevent irreparable damage to the lock when force in excess of that specified in ANSI/BHMA A156.13 is applied to the lever handle. Provide lever handles return to within 13mm (1/2 inch) of the door face.

2.3.9.3 Texture

Provide knurled or abrasive coated knobs or lever handles for doors which are accessible to blind persons and which lead to dangerous areas.

2.3.10 Keys

Furnish one file key, one duplicate key, and one working key for each key change. Furnish one additional working key for each lock of each keyed-alike group. Stamp each key with appropriate key control symbol and "U.S. property - Do not duplicate." Do not place room number on keys.

2.3.11 CARD KEY ACCESS CONTROL

A total of six systems shall be provided. Each system shall include electronic card lockset with lever handles as scheduled, card reader as scheduled, dedicated portable lock interrogation and programming unit, dedicated compact computer with software, check-in station and card keys, remote controllers, and all other accessory items. The card key access control system shall be able to support cross-keying requirements.

2.3.11.1 Mortise Lock

Locksets shall be mortise type, tamper resistant with one-inch throw hardened steel insert dead bolt, 3/4-inch throw latch bolt, 2-3/4 inch auxiliary dead bolting latch backset. Finish of lock shall be satin chromium plated, 626, on base metal of brass or bronze. Lever handles shall be provided.

2.3.11.2 Card Reader

Card reader shall be fully weatherproof, waterproof, and shall be of slender modular design to fit on the door frame. Controller Box, Power Supply Box, and Transformer shall be provided with the card reader.

2.3.11.3 Dedicated Portable Lock Interrogation and Programming Unit

Battery powered unit with additional external power pack for programming or viewing and downloading the last 100 lock events from the audit trail. Unit shall include a connection to the server to allow report printing.

2.3.11.4 Dedicated Compact Computer with Internal Modem

Small computer server with proprietary software with customized defaults, password protected data files, internal modem, parallel printer port for system printer shall be provided of each check-in station.

2.3.11.5 Check-in Station and Card Keys

Provide a total of 5 check-in stations for encoding cards. Provide a minimum of 6,000 blank cards, consisting of 3,000 each of 2 different customized designs, with ANSI or ISO standard magnetic strips. Cards shall resist tearing, scratching and shall be water resistant.

2.3.11.6 Door Hardware

Provide door hardware which can be reprogrammed for future software changes at the door units without replacement of original lock components. Magnetic cards shall be programmed on a time basis only to eliminate out of sequence cards.

2.3.11.7 Extra Materials

Extra Electronic Card Locksets shall be furnished at the rate of 2 locksets for each 100 locksets installed. Extra locksets shall be same as those installed.

2.3.12 Door Bolts

ANSI/BHMA A156.16 or KS F 4525. Provide dust-proof strikes for bottom bolts, except for doors having metal thresholds. Automatic latching flush bolts: ANSI/BHMA A156.3, Type 25.

2.3.13 Closers

ANSI/BHMA A156.4, Series C02000, Grade 1, with PT 4C, or KS F 4505. Provide with brackets, arms, mounting devices, fasteners, full size covers, except at storefront mounting, pivots, cement cases, and other features necessary for the particular application. Size closers in accordance with manufacturer's recommendations, or provide multi-size closers, Sizes 1 through 6, and list sizes in the Hardware Schedule. Provide manufacturer's 10 year warranty.

2.3.13.1 Identification Marking

Engrave each closer with manufacturer's name or trademark, date of manufacture, and manufacturer's size designation located to be visible after installation.

2.3.14 Overhead Holders

ANSI/BHMA A156.8.

2.3.15 Closer Holder-Release Devices

ANSI/BHMA A156.15.

2.3.16 Door Protection Plates

ANSI/BHMA A156.6.

2.3.16.1 Sizes of Armor, Mop, and Kick Plates

50 mm (2 inch) less than door width for single doors; 25 mm (1 inch) less than door width for pairs of doors. Provide 200 or 250 mm (8 or 10 inch) kick plates for flush doors and 25 mm (1 inch) less than height of bottom rail for panel doors, where designed. Provide a minimum 900 mm (36 inch) armor plates for flush doors and completely cover lower panels of panel doors, except 400 mm (16 inch) high armor plates on fire doors. Provide 150 mm (6 inch) mop plates.

2.3.17 Edge Guards

ANSI/BHMA A156.6, stainless steel, of same height as armor plates. Apply to meeting stiles.

2.3.18 Door Stops and Silencers

ANSI/BHMA A156.16 or KS F 4525. Silencers Type L03011. Provide three silencers for each single door, two for each pair.

2.3.19 Padlocks

ASTM F883.

2.3.20 Thresholds

ANSI/BHMA A156.21. Use J35100, with vinyl or silicone rubber insert in face of stop, for exterior doors opening out, unless specified otherwise.

2.3.21 Weather Stripping Gasketing

ANSI/BHMA A156.22. Provide the type and function designation where specified in paragraph entitled "Hardware Schedule". Provide a set to include head and jamb seals, sweep strips, and, for pairs of doors, astragals. Air leakage of weather stripped doors not to exceed 2.19 by 10-5 cms per square meter (0.5 cfm per square feet) of door area when tested in accordance with ASTM E283. Provide weather stripping with one of the following:

2.3.21.1 Extruded Aluminum Retainers

Extruded aluminum retainers not less than 1.25 mm (0.050 inch) wall thickness with vinyl, neoprene, silicone rubber, or polyurethane inserts. Provide clear (natural) anodized aluminum.

2.3.21.2 Interlocking Type

Zinc or bronze not less than 0.45 mm (0.018 inch) thick.

2.3.21.3 Spring Tension Type

Spring bronze or stainless steel not less than 0.20 mm (0.008 inch) thick.

2.3.22 Light-proofing and Soundproofing Gasketing

ANSI/BHMA A156.22. Include adjustable doorstops at head and jambs and an automatic door bottom per set, both of extruded aluminum, clear (natural) anodized, surface applied, with vinyl fin seals between plunger and housing. Provide doorstops with solid neoprene tube, silicone rubber, or closed-cell sponge gasket. Furnish door bottoms with adjustable operating rod and silicone rubber or closed-cell sponge neoprene gasket. Doorstops mitered at corners. Provide the type and function designation where specified in paragraph entitled "Hardware Sets".

2.3.23 Rain Drips

Extruded aluminum, not less than 2.03 mm (0.08 inch) thick, clear anodized. Set drips in sealant and fasten with stainless steel screws.

2.3.23.1 Door Rain Drips

Approximately 38 mm high by 16 mm (1-1/2 inch high by 5/8 inch) projection. Align bottom with bottom edge of door.

2.3.23.2 Overhead Rain Drips

Approximately 38 mm high by 64 mm (1-1/2 inch high by 2-1/2 inch) projection, with length equal to overall width of door frame. Align bottom with door frame rabbet.

2.3.24 Special Tools

Provide special tools, such as spanner and socket wrenches and dogging keys, required to service and adjust hardware items.

2.4 FASTENERS

Provide fasteners of proper type, quality, size, quantity, and finish with hardware. Provide stainless steel or nonferrous metal fasteners that are exposed to weather. Provide fasteners of type necessary to accomplish a permanent installation.

2.5 FINISHES

ANSI/BHMA A156.18. Provide hardware in BHMA 630 finish (satin stainless steel), unless specified otherwise. Provide items not manufactured in stainless steel in BHMA 626 finish (satin chromium plated) over brass or bronze, except prime coat finish for surface door closers, and except BHMA 652 finish (satin chromium plated) for steel hinges. Provide hinges for exterior doors in stainless steel with BHMA 630 finish or chromium plated brass or bronze with BHMA 626 finish. Furnish exit devices in BHMA 626 finish in lieu of BHMA 630 finish. Match exposed parts of concealed closers to lock and door trim. Match hardware finish for aluminum doors to the doors.

2.6 KEY CABINET AND CONTROL SYSTEM

ANSI/BHMA A156.5, Type E8331 (25 hooks). Type required to yield a capacity (number of hooks) 50 percent greater than the number of key changes used for door locks.

2.7 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Install hardware in accordance with manufacturers' printed installation instructions. Fasten hardware to wood surfaces with full-threaded wood screws or sheet metal screws. Provide machine screws set in expansion shields for fastening hardware to solid concrete and masonry surfaces. Provide toggle bolts where required for fastening to hollow core construction. Provide through bolts where necessary for satisfactory installation.

3.1.1 Weather Stripping Installation

Handle and install weather stripping to prevent damage. Provide full contact, weather-tight seals. Operate doors without binding.

3.1.1.1 Stop-Applied Weather Stripping

Fasten in place with color-matched sheet metal screws not more than 225 mm (9 inch) on center after doors and frames have been finish painted.

3.1.1.2 Interlocking Type Weather Stripping

Provide interlocking, self-adjusting type on heads and jambs and flexible hook type at sills. Nail weather stripping to door 25 mm (1 inch) on center and to heads and jambs at 100 mm (4 inch) on center

3.1.1.3 Spring Tension Type Weather Stripping

Provide spring tension type on heads and jambs. Provide bronze nails with bronze, stainless steel nails with stainless steel. Space nails not more than 38 mm (1-1/2 inch) on center.

3.1.2 Light-proofing and Soundproofing Installation

Install as specified for stop-applied weather stripping.

3.1.3 Threshold Installation

Extend thresholds the full width of the opening and notch end for jamb stops. Set thresholds in a full bed of sealant and anchor to floor with cadmium-plated, countersunk, steel screws in expansion sleeves.

3.2 FIRE DOORS AND EXIT DOORS

Install hardware in accordance with NFPA 80 for fire doors, NFPA 101 for exit doors.

3.3 HARDWARE LOCATIONS

SDI/DOOR A250.8, unless indicated or specified otherwise.

a. Kick and Armor Plates: Push side of single-acting doors. Both sides of double-acting doors.

b. Mop Plates: Bottom flush with bottom of door.

3.4 KEY CABINET AND CONTROL SYSTEM

Locate where directed. Tag one set of file keys and one set of duplicate keys. Place other keys in appropriately marked envelopes, or tag each key. Furnish complete instructions for setup and use of key control system. On tags and envelopes, indicate door and room numbers or master or grand master key.

3.5 FIELD QUALITY CONTROL

After installation, protect hardware from paint, stains, blemishes, and other damage until acceptance of work. Submit notice of testing 15 days before scheduled, so that testing can be witnessed by the Contracting Officer. Adjust hinges, locks, latches, bolts, holders, closers, and other items to operate properly. Demonstrate that permanent keys operate respective locks, and give keys to the Contracting Officer. Correct, repair, and finish, as directed, errors in cutting and fitting and damage to adjoining work.

3.6 HARDWARE SETS

Provide hardware for aluminum doors under this section. Deliver Hardware templates and hardware, except field-applied hardware to the aluminum door and frame manufacturer for use in fabricating the doors and frames.

-- End of Section --

SECTION 08 81 00

GLAZING
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1	(2009; Errata 2010) Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

ASTM INTERNATIONAL (ASTM)

ASTM C1036	(2010; E 2012) Standard Specification for Flat Glass
ASTM C1048	(2004) Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass
ASTM C1172	(2009e1) Standard Specification for Laminated Architectural Flat Glass
ASTM C509	(2006; R 2011) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM C864	(2005; R 2011) Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D2287	(2011) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM D395	(2003; R 2008) Standard Test Methods for Rubber Property - Compression Set
ASTM D4802	(2010) Poly(Methyl Methacrylate) Acrylic Plastic Sheet
ASTM E119	(2012a) Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E1300	(2009a) Determining Load Resistance of Glass in Buildings

ASTM E2226	(2011) Standard Practice for Application of Hose Stream

GLASS ASSOCIATION OF NORTH AMERICA (GANA)

GANA Glazing Manual	(2004) Glazing Manual
GANA Sealant Manual	(2008) Sealant Manual
GANA Standards Manual	(2001) Tempering Division's Engineering Standards Manual

INSULATING GLASS MANUFACTURERS ALLIANCE (IGMA)

IGMA TB-3001	(1990) Guidelines for Sloped Glazing
IGMA TM-3000	(1997) Glazing Guidelines for Sealed Insulating Glass Units
IGMA TR-1200	(1983) Commercial Insulating Glass Dimensional Tolerances

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3204	(2005) Oil Based Calking Compounds for Buildings
KS L 2002	(2006) Tempered Glass
KS L 2004	(2009) Laminated Glass
KS L 2008	(2003) Heat Absorbing Glasses
KS L 2012	(2007) Float and Polished Plate Glasses
KS L 2015	(2006) Heat-Strengthened Glass
KS L 2104	(2009) Glass for Mirror
KS M 3811	(2006) Polymethyl Methacrylate Sheets

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 252	(2008) Standard Methods of Fire Tests of Door Assemblies
NFPA 257	(2007) Standard on Fire Test for Window and Glass Block Assemblies
NFPA 80	(2013) Standard for Fire Doors and Other Opening Protectives

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1201	Safety Standard for Architectural Glazing Materials

UNDERWRITERS LABORATORIES (UL)

UL 752	(2005; Reprint Jul 2011) Standard for Bullet-Resisting Equipment
UL MEAPD	(2011) Mechanical Equipment and Associated Products Directory (online version is listed under Certifications at www.ul.com)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation

SD-03 Product Data

Insulating Glass
Plastic Glazing
Warranty

1.3 SYSTEM DESCRIPTION

Glazing systems shall be fabricated and installed watertight and airtight to withstand thermal movement and wind loading without glass breakage, gasket failure, deterioration of glazing accessories, and defects in the work. Glazed panels shall comply with the safety standards, as indicated in accordance with ANSI Z97.1. Glazed panels shall comply with indicated wind/snow loading in accordance with ASTM E1300.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver products to the site in unopened containers, labeled plainly with manufacturers' names and brands. Store glass and setting materials in safe, enclosed dry locations and do not unpack until needed for installation. Handle and install materials in a manner that will protect them from damage.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not start glazing work until the outdoor temperature is above 4 degrees C (40 degrees F) and rising, unless procedures recommended by the glass manufacturer and approved by the Contracting Officer are made to warm the glass and rabbet surfaces. Provide ventilation to prevent condensation of moisture on glazing work during installation. Do not perform glazing work during damp or rainy weather.

1.6 SHOP DRWAINGS

Submit installation drawings showing complete details of the proposed setting methods, mullion details, edge blocking, size of openings, frame details, materials, and types and thickness of glass.

1.7 WARRANTY

1.7.1 Warranty for Insulating Glass Units

Warranty insulating glass units against development of material obstruction to vision (such as dust, fogging, or film formation on the inner glass surfaces) caused by failure of the hermetic seal, other than through glass breakage, for a 10-year period following acceptance of the work. Provide new units for any units failing to comply with terms of this warranty within 45 working days after receipt of notice from the Government.

1.7.2 Warranty for Polycarbonate Sheet

For a 5-year period following acceptance of the work:

a. Warranty Type I, Class A (UV stabilized) sheets against breakage;

b. Warranty Type III (coated, mar-resistant) sheets against breakage and against coating delamination;

c. Warranty Type IV (coated sheet) against breakage and against yellowing;

d. Warranty extruded polycarbonate profile sheet against breakage.

For a 10-year period following acceptance of the work, warranty Type IV against yellowing and loss of light transmission.

PART 2 PRODUCTS

2.1 GLASS

ASTM C1036, unless specified otherwise. In doors and sidelights, provide safety glazing material conforming to 16 CFR 1201.

2.1.1 Clear Glass

For interior glazing (i.e., pass and observation windows), 6 mm (1/4 inch) thick glass should be used except otherwise indicated.

Type I, Class 1 (clear), Quality q4 (A). Provide for glazing openings not indicated or specified otherwise. Use double-strength sheet glass or 3 mm (1/8 inch) float glass for openings up to and including 1.39 square meters (15 square feet), 4.5 mm (3/16 inch) for glazing openings over 1.39 square meters (15 square feet) but not over 2.79 square meters (30 square feet), and 6 mm (1/4 inch) for glazing openings over 2.79 square meters (30 square feet) but not over 4.18 square meters (45 square feet).

2.1.2 Annealed Glass

Annealed glass shall be Type I transparent flat type, Class 1 - clear, Quality q3 - glazing select, conforming to ASTM C1036 or KS L 2012. Color shall be gray, unless otherwise indicated.

2.1.3 Heat-Absorbing Glass

Type I, Class 2 (heat absorbing and light reducing), Quality q3 (select), thickness, color, light transmission, and shading coefficient as indicated, conforming to ASTM C1036 or KS L 2008. Color shall be gray for

6 mm (1/4 inch) thickness.

2.1.4 Wired Glass

Glass for fire-rated windows shall be UL listed and shall be rated for 45 minutes when tested in accordance with ASTM E2226. Unless otherwise indicated, wired glass shall be Type II flat type, Class 1 - translucent, Form 1 - wired and polished both sides, conforming to ASTM C1036. Wire mesh shall be polished stainless steel Mesh 1 - diamond. Wired glass for fire-rated windows shall bear an identifying UL label or the label of a nationally recognized testing agency, and shall be rated for 20 minutes when tested in accordance with NFPA 257. Wired glass for fire-rated doors shall be tested as part of a door assembly in accordance with NFPA 252.

2.1.5 Patterned Glass

Type II, Class 1 (translucent), Form 3 (patterned), Quality q7 (decorative), Finish f1 (patterned one side), Pattern p1 (linear). 3 or 6 mm (1/8 or 7/32 inch) thick, as indicated.

2.1.6 Laminated Glass

ASTM C1172, Kind LA fabricated from two nominal 3 mm (1/8 inch) pieces of Type I, Class 1, Quality q3, flat annealed transparent glass conforming to ASTM C1036 or KS L 2004. Flat glass shall be laminated together with a minimum of 0.75 mm (0.030 inch)thick, clear polyvinyl butyral interlayer. When force protection minimum measures are required, use minimum 1.5 mm (0.06 inch) thick polyvinyl butyral interlayer or approved alternatives. The total thickness shall be nominally 6 mm (1/4 inch). Color shall be clear unless otherwise indicated.

2.1.7 Bullet-Resisting Glass

Fabricated from Type I, Class 1, Quality q3 glass with polyvinyl butyral plastic layers between the layers of glass and listed by UL MEAPD as bullet resisting, with a power rating of High--Rifle, unless otherwise indicated, in accordance with UL 752.

2.1.8 Mirrors

2.1.8.1 Glass Mirrors

Glass for mirrors shall be Type I transparent flat type, Class 1-clear, Glazing Quality q1 6 mm (1/4 inch) thick conforming to ASTM C1036 or KS L 2104. Glass shall be coated on one surface with silver coating, copper protective coating, and mirror backing paint. Silver coating shall be highly adhesive pure silver coating of a thickness which shall provide reflectivity of 83 percent or more of incident light when viewed through 6 mm (1/4 inch) thick glass, and shall be free of pinholes or other defects. Copper protective coating shall be pure bright reflective copper, homogeneous without sludge, pinholes or other defects, and shall be of proper thickness to prevent "adhesion pull" by mirror backing paint. Mirror backing paint shall consist of two coats of special scratch and abrasion-resistant paint , and shall be baked in uniform thickness to provide a protection for silver and copper coatings which will permit normal cutting and edge fabrication.

2.1.9 One-Way Vision Glass (Transparent Mirrors)

Type I, Class 1, Quality q1, 6 mm (1/4 inch) thick, coated on one face with a hard, adherent film of chromium or other approved coating of equal durability. Glass shall transmit not less than 5 percent or more than 11 percent of total incident visible light and shall reflect from the front surface of the coating not less than 45 percent of the total incident visible light.

2.1.10 Tempered Glass

ASTM C1048 or KS L 2002, Kind FT (fully tempered), Condition A (uncoated), Type I, Class 1 (transparent), Quality q3 conforming to ASTM C1048 and GANA Standards Manual. Color shall be clear unless otherwise indicated.

2.1.11 Heat-Strengthened Glass

ASTM C1048, Kind HS (heat strengthened), Condition A (uncoated), Type I, Class 1 (clear), Quality q3 or KS L 2015.

2.1.12 Spandrel Glass

2.1.12.1 Ceramic-Opacified Spandrel Glass

Ceramic-opacified spandrel glass shall be Kind HS heat-strengthened transparent flat type, Condition B, coated with a colored ceramic material on No. 2 surface, Quality q3 - glazing select,conforming to ASTM C1048. Glass performance (K-Value/Winter Nighttime (R-Value/Winter Nighttime), shading coefficient) and color shall be as indicated.

2.1.12.2 Film-Opacified Spandrel Glass

Film-opacified spandrel glass shall be Kind HS heat-strengthened transparent flat type, Quality q3 - glazing select, Condition C glass with a polyester or polyethylene film 0.025 mm to 0.127 mm (2 mils to 5 mils) thick attached to No. 2 surface of a sputtered solar-reflective film, conforming to ASTM C1048. Film opacification shall be compatible to and specifically developed for application to solar reflective films.

2.1.12.3 Spandrel Glass With Adhered Backing

ASTM C1048, Kind HS or FT, Condition B (ceramic coated), Type I, Quality q5, and shall pass the fallout resistance test specified in ASTM C1048.

2.1.13 Fire/Safety Rated Glass

Fire/safety rated glass shall be laminated Type I transparent flat type, Class 1-clear. Glass shall have a 20 minute rating when tested in accordance with ASTM E119. Glass shall be permanently labeled with appropriate markings.

2.1.14 Tinted (Light-Reducing) Glass

Tinted (light-reducing) glass shall be Type I transparent flat type, Class 3-tinted, Quality q3 - glazing select, 47 percent light transmittance, 0.59 percent shading coefficient, conforming to ASTM C1036. Color shall be gray.

2.2 INSULATING GLASS UNITS

Two panes of glass separated by a dehydrated airspace and hermetically sealed. Dimensional tolerances shall be as specified in IGMA TR-1200. Spacer shall be roll-formed, with bent or tightly welded or keyed and sealed joints to completely seal the spacer periphery and eliminate moisture and hydrocarbon vapor transmission into airspace through the corners. Primary seal shall be compressed polyisobutylene and the secondary seal shall be a specially formulated silicone.

2.2.1 Buildings

Two panes of glass separated by a dehydrated airspace and hermetically sealed. Dimensional tolerances shall be as specified in IGMA TR-1200. Spacer shall be black, roll-formed, thin-gauge C-section steel, steel-reinforced butyl rubber, thermally broken aluminum, or polyurethane and silicon foams, as indicated, with bent or tightly welded or keyed and sealed joints to completely seal the spacer periphery and eliminate moisture and hydrocarbon vapor transmission into airspace through the corners. Primary seal shall be compressed polyisobutylene and the secondary seal shall be a specially formulated silicone.

The inner light shall be ASTM C1172, clear annealed flat glass Type I, Class I, Quality q3, unless otherwise indicated. The outer light shall be ASTM C1036, Type I, Class 1 (transparent), Quality q4, unless otherwise indicated.

2.2.2 Low Emissivity Insulating Glass

Interior and exterior glass panes for Low-E insulating units shall be Type I annealed flat glass, Class 1-clear with anti-reflective low-emissivity coating on No. 2 surface (inside surface of exterior pane), Quality q3 - glazing select, conforming to ASTM C1036. Glass performance (U value maximum, Solar Heat Gain Coefficient)shall be as indicated . Color shall be gray.

2.3 PLASTIC GLAZING

Plastic glazing shall have a U-factor maximum as indicated. Plastic glazing shall include a 16 mm (0.63 inch) layer of aerogel between panels where indicated.

2.3.1 Acrylic Sheet

ASTM D4802 or KS M 3811, Type II, heat resistant, clear and smooth on both sides, ultraviolet stabilized, 6 mm (0.236 in.) thick, unless otherwise indicated.

2.3.2 Polycarbonate Sheet

ANSI Z97.1, Clear and smooth both sides gray tint, high abrasion resistant, ultraviolet stabilized, thickness as indicated and listed in UL MEAPD as burglar resisting.

2.3.3 Extruded Polycarbonate Profiled Sheet

Provide double walled, surface treated for improved UV resistance, offering thermal efficiency and impact strength.

2.3.4 Bullet-Resistant Plastic Sheet

Cast acrylic sheet or mar-resistant polycarbonate sheet laminated with a special interlayer, and listed in UL 752 as bullet resisting, Class I, unless otherwise indicated.

2.4 SETTING AND SEALING MATERIALS

Provide as specified in the GANA Glazing Manual, IGMA TM-3000, IGMA TB-3001, and manufacturer's recommendations, unless specified otherwise herein. Do not use metal sash putty, non-skinning compounds, non-resilient preformed sealers, or impregnated preformed gaskets. Materials exposed to view and unpainted shall be gray or neutral color.

2.4.1 Putty and Glazing Compound

Glazing compound shall be as recommended by manufacturer for face-glazing metal sash. Putty shall be linseed oil type. Putty and glazing compounds shall not be used with insulating glass or laminated glass.

2.4.2 Glazing Compound

Use for face glazing metal sash. Do not use with insulating glass units or laminated glass.

2.4.3 Sealants

Provide elastomeric sealants, unless otherwise indicated. ASTM C920, Type S, Grade NS, Class 12.5, Use G, or KS F 3204. Use for channel or stop glazing metal sash. Sealant shall be chemically compatible with setting blocks, edge blocks, and sealing tapes, with sealants used in manufacture of insulating glass units. Color of sealant shall be as selected.

2.4.4 Preformed Channels

Neoprene, vinyl, or rubber, as recommended by the glass manufacturer for the particular condition. Channels for bullet-resistant glass shall be synthetic rubber, ASTM C864, not less than 6 mm (1/4 inch) thick and sufficiently resilient to accommodate expansion and contraction while maintaining a vaportight seal between glass and frame. Channels shall be chemically compatible with plastic sheet.

2.4.5 Sealing Tapes

Preformed, semisolid, PVC-based material of proper size and compressibility for the particular condition, complying with ASTM D2287. Use only where glazing rabbet is designed for tape and tape is recommended by the glass or sealant manufacturer. Provide spacer shims for use with compressible tapes. Tapes shall be chemically compatible with the product being set.

2.4.6 Setting Blocks and Edge Blocks

Closed-cell neoprene setting blocks shall be dense extruded type conforming to ASTM C509 and ASTM D395, Method B, Shore A durometer between 70 and 90. Edge blocking shall be Shore A durometer of 50 (plus or minus 5). Silicone setting blocks shall be required when blocks are in contact with silicone sealant. Profiles, lengths and locations shall be as required and recommended in writing by glass manufacturer. Block color shall be black.

2.4.7 Glazing Gaskets

Glazing gaskets shall be extruded with continuous integral locking projection designed to engage into metal glass holding members to provide a watertight seal during dynamic loading, building movements and thermal movements. Glazing gaskets for a single glazed opening shall be continuous one-piece units with factory-fabricated injection-molded corners free of flashing and burrs. Glazing gaskets shall be in lengths or units recommended by manufacturer to ensure against pull-back at corners. Glazing gasket profiles shall be as indicated on drawings.

2.4.7.1 Fixed Glazing Gaskets

Fixed glazing gaskets shall be closed-cell (sponge) smooth extruded compression gaskets of cured elastomeric virgin neoprene compounds conforming to ASTM C509, Type 2, Option 1.

2.4.7.2 Wedge Glazing Gaskets

Wedge glazing gaskets shall be high-quality extrusions of cured elastomeric virgin neoprene compounds, ozone resistant, conforming to ASTM C864, Option 1, Shore A durometer between 65 and 75.

2.4.7.3 Aluminum Framing Glazing Gaskets

Glazing gaskets for aluminum framing shall be permanent, elastic, non-shrinking, non-migrating, watertight and weathertight.

2.4.8 Accessories

Provide as required for a complete installation, including glazing points, clips, shims, angles, beads, and spacer strips. Provide non-corroding metal accessories. Provide primer-sealers and cleaners as recommended by the glass and sealant manufacturers.

2.5 MIRROR ACCESSORIES

2.5.1 Mastic

Mastic for setting mirrors shall be a polymer type mirror mastic resistant to water, shock, cracking, vibration and thermal expansion. Mastic shall be compatible with mirror backing paint, and shall be approved by mirror manufacturer.

2.5.2 Mirror Frames

Mirrors shall be provided with mirror frames (J-mold channels) fabricated of one-piece roll-formed Type 304 stainless steel with No. 4 brushed satin finish and concealed fasteners which will keep mirrors snug to wall. Frames shall be 32 by 6 by 6 mm (1-1/4 by 1/4 by 1/4 inch) continuous at top and bottom of mirrors. Concealed fasteners of type to suit wall construction material shall be provided with mirror frames.

2.5.3 Mirror Clips

Concealed fasteners of type to suit wall construction material shall be provided with clips.

2.6 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated in above paragraph under the contractor's quality control approval. These materials should be certified and listed in Korean Industrial Standards (KS) as a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Preparation, unless otherwise specified or approved, shall conform to applicable recommendations in the GANA Glazing Manual, GANA Sealant Manual, IGMA TB-3001, IGMA TM-3000, and manufacturer's recommendations. Determine the sizes to provide the required edge clearances by measuring the actual opening to receive the glass. Grind smooth in the shop glass edges that will be exposed in finish work. Leave labels in place until the installation is approved, except remove applied labels on heat-absorbing glass and on insulating glass units as soon as glass is installed. Securely fix movable items or keep in a closed and locked position until glazing compound has thoroughly set.

3.2 GLASS SETTING

Shop glaze or field glaze items to be glazed using glass of the quality and thickness specified or indicated. Glazing, unless otherwise specified or approved, shall conform to applicable recommendations in the GANA Glazing Manual, GANA Sealant Manual, IGMA TB-3001, IGMA TM-3000, and manufacturer's recommendations. Aluminum windows, wood doors, and wood windows may be glazed in conformance with one of the glazing methods described in the standards under which they are produced, except that face puttying with no bedding will not be permitted. Handle and install glazing materials in accordance with manufacturer's instructions. Use beads or stops which are furnished with items to be glazed to secure the glass in place. Verify products are properly installed, connected, and adjusted.

3.2.1 Sheet Glass

Cut and set with the visible lines or waves horizontal.

3.2.2 Patterned Glass

Set glass with one patterned surface with smooth surface on the weather side. When used for interior partitions, place the patterned surface in same direction in all openings.

3.2.3 Insulating Glass Units

Do not grind, nip, or cut edges or corners of units after the units have left the factory. Springing, forcing, or twisting of units during setting will not be permitted. Handle units so as not to strike frames or other objects. Installation shall conform to applicable recommendations of IGMA TB-3001 and IGMA TM-3000.

3.2.4 Installation of Wire Glass

Install glass for fire doors in accordance with installation requirements of NFPA 80.

3.2.5 Installation of Heat-Absorbing Glass

Glass shall have clean-cut, factory-fabricated edges. Field cutting will not be permitted.

3.2.6 Installation of Laminated Glass

Sashes which are to receive laminated glass shall be weeped to the outside to allow water drainage into the channel.

3.2.7 Plastic Sheet

Conform to manufacturer's recommendations for edge clearance, type of sealant and tape, and method of installation.

3.3 ADDITIONAL REQUIREMENTS FOR GLAZING CONTROL TOWER WINDOWS

3.3.1 Materials and Methods of Installation

Comply with the manufacturer's warranty and written instructions, except as indicated. Install units with the heat-absorbing glass to the exterior. Secure glass in place with bolts and spring clips. The minimum clearance between bolts and edge of glass unit shall be 4.75 mm (3/16 inch). The glass shall be edged with 4.75 mm (3/16 inch) thick continuous neoprene, vinyl, or other approved material. Trim edging after installation. The channel shapes or strips shall be firmly held against the glass by the spring action of the extruded metal moldings. Resilient setting blocks, spacer strips, clips, bolts, washers, angles, applicable glazing compound, and resilient channels or cemented-on materials shall be as recommended in the written instructions of the glass manufacturer, as approved.

3.3.2 Tolerances and Clearances of Units

Design to prevent the transfer of stress in the setting frames to the glass. Springing, twisting, or forcing of units during setting will not be permitted.

3.4 CLEANING

Clean glass surfaces and remove labels, paint spots, putty, and other defacement as required to prevent staining. Glass shall be clean at the time the work is accepted. Clean plastic sheet in accordance with manufacturer's instructions.

3.5 PROTECTION

Glass work shall be protected immediately after installation. Glazed openings shall be identified with suitable warning tapes, cloth or paper flags, attached with non-staining adhesives. Reflective glass shall be protected with a protective material to eliminate any contamination of the reflective coating. Protective material shall be placed far enough away from the coated glass to allow air to circulate to reduce heat buildup and moisture accumulation on the glass. Glass units which are broken, chipped, cracked, abraded, or otherwise damaged during construction activities shall be removed and replaced with new units.

3.6 WASTE MANAGEMENT

Disposal and recycling of waste materials, including corrugated cardboard recycling, shall be in accordance with the Waste Management Plan. Close and seal tightly all partly used sealant containers and store protected in well-ventilated, fire-safe area at moderate temperature.

3.7 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Glass	1/8 inch	3 mm
	3/16 inch	4.5 mm
	7/32 inch	6 mm
	1/4 inch	6 mm
	3/8 inch	10 mm
Interlayer	0.015 inch	0.38 mm
Glazing Channels	1/4 inch	6 mm

-- End of Section --

SECTION 08 87 16

FRAGMENT RETENTION FILM FOR GLASS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1	(2009; Errata 2010) Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

ASTM INTERNATIONAL (ASTM)

ASTM C1036	(2010; E 2012) Standard Specification for Flat Glass
ASTM C1048	(2004) Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass
ASTM D1044	(2008e1) Resistance of Transparent Plastics to Surface Abrasion
ASTM D3330/D3330M	(2004; R 2010) Peel Adhesion of Pressure-Sensitive Tape
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

GLASS ASSOCIATION OF NORTH AMERICA (GANA)

GANA Glazing Manual	(2004) Glazing Manual
GANA Sealant Manual	(2008) Sealant Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1201	Safety Standard for Architectural Glazing Materials

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The applied fragment retention film shall be clean and free of peeling, splitting, scratches, creases, wrinkles, discoloration, and foreign particles. The film application shall be free of air bubbles after 30 days. Fragment retention film shall not show signs of waviness and distortion at the time the work is accepted. This determination shall be made by the unaided eye (except for corrective prescription glasses), when the film is viewed from a distance of 3 m (10 feet) from the interior room side at angles up to 45 degrees when looking at a clear or uniformly overcast sky. Unacceptable fragment retention film applications shall be removed in accordance with manufacturer's instructions and new film applied.

1.2.2 Other Submittals Requirements

The following shall be submitted for fragment retention film:

a. Manufacturer's data consisting of catalog cuts, brochures, circulars, and a list of glazing compounds and/or gaskets known to be incompatible with the fragment retention film.

b. Manufacturer's application and cleaning instructions for fragment retention film.

c. A statement that the fragment retention film supplied was manufactured using the same materials and process as the material tested. A statement that the adhesive contains ultraviolet inhibitors which limit ultraviolet transmission to not more than 8 percent of the radiation between 300 and 380 nanometers. A statement that the film manufacturer or manufacturer's representative trained the personnel who will apply the film.

d. Certified test reports including analysis and interpretation of test results. Each report shall identify the manufacturer, the specific product name, the film thickness, the adhesive type and thickness, and the glass type and thickness. Test reports shall clearly identify the methods used and shall include the results recorded.

e. On applications where the film will contact the glazing beads or gaskets, a certificate from the Contractor stating that the glazing compounds and gaskets are compatible with the fragment retention film and adhesive.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fragment Retention Film

Warranty

SD-06 Test Reports

Certified Test Reports
Impact Performance

SD-07 Certificates

Manufacturer's Statement

SD-08 Manufacturer's Instructions

Application and Cleaning Instructions

1.4 QUALITY ASSURANCE

The personnel applying the fragment retention film shall be trained by the film manufacturer or manufacturer's representative.

1.5 DELIVERY, STORAGE, AND HANDLING

The Contractor is responsible for delivery of the fragment retention film to the appropriate location for application. Fragment retention film shall be delivered, stored, and handled in accordance with the manufacturer's recommendations. Store glass, including glass in windows or doors with factory applied film, in a dry location free of dust, water, and other contaminants. Glass with factory applied film shall be delivered, stored, and handled so that the film is not damaged, scratched, or abraded and shall be stored in a manner which permits easy access for inspection and handling. Provide each roll of film with a tamperproof label containing full details of the roll, the batch number, and sufficient information to enable the Contracting Officer to ensure that the correct film is supplied.

1.6 WARRANTY

Furnish a 5 year warranty for fragment retention film material, providing for replacement of film if cracking, crazing, peeling, or inadequate adhesion occurs.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide fragment retention film which is the standard product of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 FRAGMENT RETENTION FILM

Fragment retention film shall be polyester, polyethylene terephthalate, or a composite, optically clear and free of waves, distortions, impurities, and adhesive lines. The film may be a single layer or laminated. Lamination of the film shall only occur at the factory of the fragment retention film manufacturer. The film shall include an abrasion resistant coating on the surface that does not receive the film adhesive. Fragment retention film shall be a minimum thickness of 0.18 mm (0.007 inch) and shall be clear. The film shall be supplied with an optically clear weatherable pressure sensitive adhesive. The adhesive shall contain ultraviolet inhibitors to protect the film for its required life and shall limit ultraviolet transmission to not more than 8 percent of the radiation between 300 and 380 nanometers. The adhesive shall not be water activated. A water soluble detackifier and/or release liner may be incorporated over the adhesive to facilitate film application. The adhesive shall be 90 percent cured within 30 days of installation. Adhesives on film thicknesses of 0.25 mm (0.010 inch) and greater shall be a minimum of 0.02 mm (0.0008 inch) thick. The following tests to indicate compliance with specified requirements shall be performed by an independent testing laboratory, and the laboratory reports shall be signed by a responsible official of the laboratory.

2.2.1 Impact Performance

Fragment retention film shall be tested for impact in accordance with ANSI Z97.1 or 16 CFR 1201. Tests shall be conducted on fragment retention film applied to 3.1 to 6.4 mm (1/8 to 1/4 inch)-thick annealed flat glass which conforms to the requirements of ASTM C1036, Type I, Class 1, Quality q3. The film tested shall be applied to the glass with a splice located at the midpoint of the specimen. Sketches showing location and configuration of splice shall be included in submitted certified test reports. After the impact portion of the test is conducted, satisfactory performance of the test specimens shall be determined using ANSI Z97.1, paragraph 5.1.3 or 16 CFR 1201, paragraph 1201.4 (e)--INTERPRETATION OF RESULTS. To be qualified for use under this specification, the manufacturer shall provide a report that the fragment retention film satisfactorily performed in accordance with ANSI Z97.1, paragraph 5.1.3 (1), (3), or (4) or with 16 CFR 1201, paragraph 1204.4 (e) (1) (i), (iv), or (v). ANSI Z97.1, paragraph 5.1.3 (2) or 16 CFR 1201, paragraph 1204.4 (e) (1) (ii) shall not constitute passing criteria.

2.2.2 Tensile Strength

The fragment retention film samples tested shall exhibit a minimum tensile strength at break of 172.4 MPa (25,000 psi) when tested in accordance with ASTM D882. Method A, Static Weighing, Constant Rate of Grip Separation Test, shall be used to conduct this test. The rate of grip separation shall not exceed 0.2 mm/s (1/2 inch per minute).

2.2.3 Peel Strength

Testing shall be conducted following 1,200 hours accelerated weathering exposure. The fragment retention film shall exhibit a minimum peel strength of 930 N/m (5.3 pounds/inch) for 0.10 mm (0.004 inch) thick film and 790 N/m (4.5 pounds/inch) for 0.18 mm (0.007 inch) thick and thicker film when tested in accordance with ASTM D3330/D3330M. Method A shall be used to conduct the tests. A glass substrate shall be used and a maximum dwell time of 45 days is permitted.

2.2.4 Surface Abrasion

The fragment retention film shall exhibit a change in haze not to exceed 3.2 percent following 100 turns, using 500-gram weights on a CS 10F abrasive wheel when tested in accordance with ASTM D1044.

2.2.5 Flame Spread and Smoke Density

The fragment retention film shall exhibit a flame spread index not exceeding 25 and a smoke density index not exceeding 100 when tested in accordance with ASTM E84. For the test, the specimen shall be mounted to 6.4 mm (1/4 inch) thick tempered glass which conforms to the requirements of ASTM C1048, Kind FT, Type I, Class 1, Quality q3.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Clean the glass surface, to which the fragment retention film is to be applied, of paint, foreign compounds, smears, and spatters. After the initial cleaning, further clean the surface to receive the film in accordance with the film manufacturer's instructions.

3.2 APPLICATION

Provide fragment retention film on window and door glass where indicated. After surface preparation, apply the fragment retention film in accordance with the manufacturer's recommendations and instructions. Film shall be applied to the interior (room) side of the glass for both single and double glazed sheets, unless otherwise indicated. Multiple applications of film to achieve specified thicknesses are not allowed. The film shall not be applied if there are visible dust particles in the air, if there is frost on the glazing, or if any room condition such as temperature and humidity do not meet the manufacturer's instructions. After film application, maintain room conditions as required by the manufacturer's instructions to allow for proper curing of the adhesive.

3.2.1 Application to New Glass Before Glazing

Apply fragment retention film so that it extends edge to edge of the glass sheet. The film reinforced glass shall then be set into the frame with glazing compounds or gaskets as specified in Section 08 81 00 GLAZING. Ensure compatibility when contact between the glazing compounds and/or gaskets and the film occurs. Coordinate fragment retention film application and curing with the glass supplier and window or door manufacturer prior to glazing installation.

3.2.2 Application to Existing Glass Involving Dismantlement

Remove the existing glazing compound, gaskets, and/or stops as required to expose the existing glass pane. If necessary, remove the glass so that the film can be applied extending edge to edge of the glass sheet. Install existing gaskets and/or stops and replace any removed glazing compounds with new glazing compounds. Removed glazing compounds shall be scrapped and not reused. Glazing compounds shall be in accordance with GANA Sealant Manual. Glazing methods shall be in accordance with GANA Glazing Manual. Ensure compatibility when contact between the glazing compounds and/or gaskets and the film occurs. Any damaged or broken glazing and gaskets shall be replaced and reinstalled in kind.

3.2.3 Application to Existing Glass Without Dismantlement

Fragment retention film shall be applied so that it extends to within 1.6 mm (1/16 inch), with a maximum of 3 mm (1/8 inch), of the edge of the visible glass area.

3.2.4 Application to Existing Glass and Frame Without Dismantlement

Apply fragment retention film past the edge of the visible glass and extend onto the frame. Amount of film overlap, edge connection to the frame, and adhesive for adhering film to frame shall be as recommended by the film manufacturer. Ensure compatibility when contact between the glazing compounds and/or gaskets and the film occurs.

3.2.5 Splicing

Splices or seams in fragment retention film are permitted only when a sheet of glass has a dimension exceeding 1.475 m (58 inches) in both directions. All seams shall be applied with a minimum overlap of 6 mm (1/4 inch) unless submitted test reports indicate impact performance is not diminished when seam is applied with a different overlap or a gap.

3.3 CLEANING

Cleaning of the fragment retention film shall be in accordance with the manufacturer's instructions.

-- End of Section --

SECTION 08 91 00

METAL WALL AND DOOR LOUVERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating
AMCA 511	(2013) Certified Ratings Program for Air Control Devices

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2603	(2002) Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels
AAMA 2604	(2005) Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels
AAMA 2605	(2005) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels
AAMA 611	(1998; R 2004) Voluntary Specification for Anodized Architectural Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 3705	(2008) Hot rolled stainless steel plates, sheets and strip
KS D 6701	(2012) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6759	(2011) Aluminum and Aluminum Alloy Extruded Shapes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Wall louvers

SD-03 Product Data

Metal Wall Louvers

1.3 DELIVERY, STORAGE, AND PROTECTION

Deliver materials to the site in an undamaged condition. Carefully store materials off the ground to provide proper ventilation, drainage, and protection against dampness. Louvers shall be free from nicks, scratches, and blemishes. Replace defective or damaged materials with new.

1.4 DETAIL DRAWINGS

Show all information necessary for fabrication and installation of wall louvers. Indicate materials, sizes, thicknesses, fastenings, and profiles.

1.5 COLOR SAMPLES

Colors of finishes for wall louvers and door louvers shall closely approximate colors indicated. Where color is not indicated, submit the manufacturer's standard colors to the Contracting Officer for selection.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Galvanized Steel Sheet

ASTM A653/A653M or KS D 3506, coating designation Z275 (G90).

2.1.2 Aluminum Sheet

ASTM B209M (ASTM B209) or KS D 6701, alloy 3003 or 5005 with temper as required for forming.

2.1.3 Extruded Aluminum

ASTM B221M (ASTM B221) or KS D 6759, alloy 6063-T5 or -T52.

2.1.4 Stainless Steel

ASTM A167 or KS D 3705, Type 302 or 304, with 2B finish.

2.1.5 Cold Rolled Steel Sheet

ASTM A1008/A1008M, Class 1, with matte finish. Use for interior louvers only.

2.2 METAL WALL LOUVERS

Weather resistant type, with bird screens and made to withstand a wind load of not less than 1.44 kilopascals (30 pounds per square foot). Wall louvers shall bear the AMCA certified ratings program seal for air performance and water penetration in accordance with AMCA 500-D and AMCA 511. The rating shall show a water penetration of 0.06 kilograms or less per square meter (0.20 or less ounce per square foot) of free area at a free velocity of 244 meters (800 feet) per minute.

2.2.1 Extruded Aluminum Louvers

Fabricated of extruded 6063-T5 or -T52 aluminum with a wall thickness of not less than 2 mm (0.081 inch).

2.2.2 Formed Metal Louvers

Formed of zinc-coated or stainless steel sheet not thinner than 16 U.S. gage, or aluminum sheet not less than 2 mm (0.08 inch) thick.

2.2.3 Mullions and Mullion Covers

Same material and finish as louvers. Provide mullions where indicated and for all louvers more than 1500 mm (5 feet) in width at not more than 1500 mm (5 feet) on centers. Provide mullions covers on both faces of joints between louvers.

2.2.4 Screens and Frames

For aluminum louvers, provide 12.5 mm (1/2 inch) square mesh, 1.8 or 1.5 mm (14 or 16 gage) aluminum or 6 mm (1/4 inch) square mesh, 1.5 mm (16 gage) aluminum bird screening. For steel louvers, provide 12.5 mm (1/2 inch) square mesh, 2.5 or 1.5 mm (12 or 16 gage) zinc-coated steel; 12.5 mm (1/2 inch) square mesh, 1.5 mm (16 gage) copper; or 6 mm (1/4 inch) square mesh, 1.5 mm thick (16 gage) zinc-coated steel or copper bird screening. Mount screens in removable, rewirable frames of same material and finish as the louvers.

2.3 DOOR LOUVERS

Inverted "Y" or Inverted "V" sight-proof type not less than 25 mm (one inch) thick with matching metal trim. Louvers for exterior doors shall be weather resistant type.

2.3.1 Extruded Aluminum Door Louvers

Fabricate of 6063-T5 or -T52 aluminum alloy with a wall thickness of not less than 1.25 mm (0.050 inch) thick. Frames and trim shall be clamp-in "L" type.

2.3.2 Formed Metal Door Louvers

Fabricate of 0.9 mm thick (20 U.S. gage) steel sheet or sheet aluminum not less than 1.25 mm (0.050 inch) thick. Trim shall be beveled "Z" molding both sides.

2.3.3 Screens and Frames

For exterior doors, provide aluminum insect screens, 18 by 16 or 18 by 14 mesh. Mount screens in removable, rewirable frames of same material and finish as the louvers.

2.4 FASTENERS AND ACCESSORIES

Provide stainless steel screws and fasteners for aluminum louvers and zinc-coated or stainless steel screws and fasteners for steel louvers. Provide other accessories as required for complete and proper installation.

2.5 FINISHES

2.5.1 Aluminum

Exposed aluminum surfaces shall be factory finished with an anodic coating or organic coating. Color shall be as indicated. Louvers shall have the same finish.

2.5.1.1 Anodic Coating

Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF45 and AAMA 611. Finish shall be Architectural Class II (0.01 to 0.0175 mm 0.4 mil to 0.7 mil), designation AA-M10-C22-A31, clear (natural), or A32, integral color, or A34, electrolytically deposited color anodized, unless otherwise indicated.

2.5.1.2 Organic Coating

Clean and prime exposed aluminum surfaces. Provide a baked enamel finish conforming to AAMA 2603, with total dry film thickness not less than 0.02 mm (0.8 mil), or high-performance finish in accordance with AAMA 2604, or AAMA 2605 with total dry film thickness of not less than 0.03 mm (1.2 mil), color as indicated.

2.5.2 Steel

Provide factory-applied coating. Clean and phosphate treat exposed surfaces and apply rust-inhibitive primer and baked enamel finish coat, 0.025 mm (one mil) minimum total dry film thickness, color as indicated.

2.6 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated in above paragraph under the contractor's quality control approval. These materials should be certified and listed in Korean Industrial Standards (KS) as a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Wall Louvers

Install using stops or moldings, flanges, strap anchors, or jamb fasteners as appropriate for the wall construction and in accordance with manufacturer's recommendations.

3.1.2 Door Louvers

Install louvers in wood doors by using metal "Z" or "L" moldings. Fasten moldings to door with screws.

3.1.3 Screens and Frames

Attach frames to louvers with screws or bolts.

3.2 PROTECTION FROM CONTACT OF DISSIMILAR MATERIALS

3.2.1 Copper or Copper-Bearing Alloys

Paint copper or copper-bearing alloys in contact with dissimilar metal with heavy-bodied bituminous paint or separate with inert membrane.

3.2.2 Aluminum

Where aluminum contacts metal other than zinc, paint the dissimilar metal with a primer and two coats of aluminum paint.

3.2.3 Metal

Paint metal in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

3.2.4 Wood

Paint wood or other absorptive materials that may become repeatedly wet and in contact with metal with two coats of aluminum paint or a coat of heavy-bodied bituminous paint.

-- End of Section --

SECTION 09 22 00

SUPPORTS FOR PLASTER AND GYPSUM BOARD

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A463/A463M	(2010) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C645	(2011a) Nonstructural Steel Framing Members
ASTM C754	(2011) Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products
ASTM C841	(2003; E 2008; R 2008) Installation of Interior Lathing and Furring
ASTM C847	(2012) Standard Specification for Metal Lath

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3609	(2012) Steel Furrings for Wall and Ceiling in Buildings

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM EMLA 920	(2009) Guide Specifications for Metal Lathing and Furring

UNDERWRITERS LABORATORIES (UL)

UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Metal support system

SD-03 Product Data

Metal Support Systems

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the job site and store in ventilated dry locations. Storage area shall permit easy access for inspection and handling. If materials are stored outdoors, stack materials off the ground, supported on a level platform, and fully protected from the weather. Handle materials carefully to prevent damage. Remove damaged items and provide new items.

1.4 Drawings

Submit metal support system shop drawings for the erection of metal framing, furring, and ceiling suspension systems. Indicate materials, sizes, thicknesses, and fastenings.

PART 2 PRODUCTS

2.1 MATERIALS

Provide steel materials for metal support systems with galvanized coating ASTM A653/A653M, Z180 (G-60); aluminum coating ASTM A463/A463M, T1-75 (T1-25); or a 55-percent aluminum-zinc coating. Provide support systems and attachments per UFC 3-310-04, "Seismic Design for Buildings" in seismic zones.

2.1.1 Materials for Attachment of Lath

2.1.1.1 Suspended and Furred Ceiling Systems and Wall Furring

ASTM C841, and ASTM C847.

2.1.1.2 Non-load bearing Wall Framing

NAAMM EMLA 920.

2.1.2 Materials for Attachment of Gypsum Wallboard

2.1.2.1 Suspended and Furred Ceiling Systems

ASTM C645 or KS D 3609.

2.1.2.2 Non load-Bearing Wall Framing and Furring

ASTM C645 or KS D 3609, but not thinner than 0.45 mm (0.0179 inch) thickness, with 0.85 mm (0.0329 inch) minimum thickness supporting wall hung items such as cabinetwork, equipment and fixtures.

2.1.2.3 Furring Structural Steel Columns

ASTM C645 or KS D 3609. Steel (furring) clips and support angles listed in UL Fire Resistance may be provided in lieu of steel studs for erection of gypsum wallboard around structural steel columns.

2.1.2.4 Z-Furring Channels with Wall Insulation

Not lighter than 0.5 mm thick (26 gage) galvanized steel, Z-shaped, with 32 mm and 19 mm (1-1/4 inch and 3/4 inch) flanges and 50 mm (2 inch) furring depth or depth as required by the insulation thickness provided.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Systems for Attachment of Lath

3.1.1.1 Suspended and Furred Ceiling Systems and Wall Furring

ASTM C841, except as indicated otherwise.

3.1.1.2 Non-load bearing Wall Framing

NAAMM EMLA 920, except provide framing members 400 mm (16 inches) o.c. unless indicated otherwise.

3.1.2 Systems for Attachment of Gypsum Wallboard

3.1.2.1 Suspended and Furred Ceiling Systems

ASTM C754, except provide framing members 400 mm (16 inches) o.c. unless indicated otherwise.

3.1.2.2 Non-load bearing Wall Framing and Furring

ASTM C754, except as indicated otherwise.

3.1.2.3 Furring Structural Steel Columns

Install studs or galvanized steel clips and support angles for erection of gypsum wallboard around structural steel columns in accordance with the UL Fire Resistance, of the fire resistance rating indicated.

3.1.2.4 Z-Furring Channels with Wall Insulation

Install Z-furring channels vertically spaced not more than 600 mm (24 inches) o.c. Locate Z-furring channels at interior and exterior corners in accordance with manufacturer's printed erection instructions. Fasten furring channels to masonry and concrete walls with powder-driven fasteners or hardened concrete steel nails through narrow flange of channel. Space fasteners not more than 600 mm (24 inches) o.c.

3.2 ERECTION TOLERANCES

Provide framing members which will be covered by finish materials such as wallboard, plaster, or ceramic tile set in a mortar setting bed, within the following limits:

a. Layout of walls and partitions: 6 mm (1/4 inch) from intended position;

b. Plates and runners: 5 mm in 1.9 meters (1/4 inch in 8 feet) from a straight line;

c. Studs: 5 mm in 1.9 meters (1/4 inch in 8 feet) out of plumb, not cumulative; and

d. Face of framing members: 5 mm in 1.9 meters (1/4 inch in 8 feet) from a true plane.

Provide framing members which will be covered by ceramic tile set in dry-set mortar, latex-portland cement mortar, or organic adhesive within the following limits:

a. Layout of walls and partitions: 6 mm (1/4 inch) from intended position;

b. Plates and runners: 5 mm in 3.8 meters (1/8 inch in 8 feet) from a straight line;

c. Studs: 5 mm in 3.8 meters (1/8 inch in 8 feet) out of plumb, not cumulative; and

d. Face of framing members: 5 mm in 3.8 meters (1/8 inch in 8 feet) from a true plane.

-- End of Section --

SECTION 09 22 36

LATH

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C1063	(2012a) Standard Practice for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
ASTM C841	(2003; E 2008; R 2008) Installation of Interior Lathing and Furring

GYPSUM ASSOCIATION (GA)

GA 600	(2009) Fire Resistance Design Manual

UNDERWRITERS LABORATORIES (UL)

UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Lath

1.3 DELIVERY AND STORAGE

Deliver materials in the manufacturer's original unbroken packages or containers that are labeled plainly with the manufacturer's names and brands. Store materials in dry locations with adequate ventilation, free from water, and in such a manner to permit easy access for inspection and handling. Stack gypsum lath flat to avoid sagging or damage to edges, ends, or surfaces, and protect from exposure to direct sunlight.

PART 2 PRODUCTS

2.1 LATH

2.1.1 Metal Plastering Base (Lath)

Provide the type(s) and weight(s) required for the type and spacing of supports shown for the kind of plaster indicated and specified. Do not use rib lath for ceramic tile scratch coat.

2.1.1.1 For Portland Cement-Based Plaster (Stucco)

ASTM C1063, diamond mesh, 10 mm (3/8 inch) rib welded wire metal lath weighing not less than 1.8 kilograms per square meter (3.4 pounds per square yard), unless otherwise indicated.

2.1.1.2 For Gypsum Plaster

ASTM C841, diamond mesh, 10 mm (3/8 inch) rib, welded wire metal lath weighing not less than 1.8 kilograms per square meter (3.4 pounds per square yard), unless otherwise indicated.

2.1.1.3 Paper Backing (Waterproofed Kraft Building Paper)

Provide metal plastering base with paper backing, "Moderate water-vapor Resistant" for room(s) or "Water-vapor permeable" for room(s) and for exterior plastering work, as indicated.

2.1.1.4 Galvanized Metal Plastering Base

Provide in all locations.

2.1.2 Gypsum Lath

ASTM C1063. Provide plain or Type X (fire resistant) gypsum lath 9.53 or 12.70 mm (3/8 or 1/2 inch) thick, as indicated.

2.1.3 Accessories

ASTM C1063 or ASTM C841. Provide only galvanized steel accessories, unless otherwise indicated.

2.2 ACCESS PANELS

Prefabricated steel units, size(s) as indicated. Fabricate frame of preformed angle or channel with welded joints. Perforate wide leg or flange of frame section or extend frame section into expanded metal wings to provide a key for the plaster. Cover shall be hinged or snap-on type with turn-latch or spring catch. Fabricate access panels not larger than 600 by 900 mm (24 by 36 inches) from 1.8 mm thick (14 gage) steel with frames not lighter than 1.5 mm thick (16 gage). Fabricate access panels larger than 600 by 900 mm (24 by 36 inches) as indicated. Factory-prime panels with rust-inhibitive paint.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSPECTION

Verify that framing, furring and accessories are securely attached and of proper sizes and spacing necessary to provide a suitable substrate to receive lath. Do not proceed with work until framing, furring and accessories are acceptable to the Contracting Officer for application of lath.

3.2 INSTALLATION

3.2.1 Lathing Materials and Accessories

Install in accordance with ASTM C1063 for portland cement-based plaster work and ASTM C841 for gypsum plaster work, except where indicated or specified otherwise herein.

3.2.1.1 Metal Plastering Base

Install where indicated to receive scratch coat for ceramic tile or terrazzo work on concrete and masonry surfaces to receive plaster.

3.2.1.2 Metal Plaster Base with Paper Backing

Where used, lap joints to provide backing on backing and metal-on-metal. Lap backing not less than 25 mm (one inch). Lap backing so that water will flow to the exterior.

3.2.1.3 Gypsum Lath

Install where indicated.

3.2.1.4 Control (Expansion and Contraction) Joints

a. For portland cement-based plaster (ceilings and walls), install to create panels no larger than 10 square meters (100 square feet) with no dimension exceeding 3150 mm (10 feet).

b. For unrestrained gypsum plaster ceilings install to create panels no larger than 250 square meters (2,500 square feet) with no dimension exceeding 15800 mm (50 feet). For gypsum plaster walls, partitions and ceilings without perimeter relief install not more than 9000 mm (30 feet) on centers in either direction.

c. Install where expansion joints occur in the structural walls and ceilings and where ceiling framing or furring changes direction. Terminate lath at each side of joint and fasten joints securely to lath.

3.2.1.5 Unrestrained Ceilings

Furred or suspended ceilings constructed with gypsum plaster and larger than 250 square meters (2,500 square feet) in area or with any dimension exceeding 15,800 mm (50 feet) or portland cement-based plaster must be unrestrained. Isolate ceiling lath and plaster from ceiling intersecting vertical surfaces with casing beads, control joints, or similar devices designed to keep the ceiling isolated from the adjacent vertical surfaces (walls, partitions, beams, and columns). Do not use corner reinforcement at the internal angle between the ceiling and the vertical surfaces.

3.2.1.6 Plastering Beads

Install edge trim (casing bead) at the edges of plaster which abuts or adjoins an unplastered surface, on each surface at the internal angle formed by load bearing and non-load bearing walls and partitions abutting structural walls, columns, or floor-ceiling slabs, between concrete or terrazzo bases and the plaster above them, on each side of the joint between walls or partitions constructed of dissimilar materials which require plastering, and between plasters of a different composition. Fill voids formed in corners with sealant. Install corner beads at all vertical external corners of plaster walls.

3.2.2 Fire-Resistant Assemblies

Wherever fire-resistant construction is indicated, provide all materials and application methods, including types and spacing of fasteners, in accordance with the specifications contained in the UL Fire Resistance for the Design Number(s) indicated or GA 600 for the File Number(s) indicated.

3.2.3 Access Panels

Install in suspended ceilings and plastered walls at locations indicated.

3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Access Panels	24 by 36 inches	600 by 900 mm
	14 gage	1.8 mm
	16 gage	1.5 mm

-- End of Section --

SECTION 09 24 23

STUCCO

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM C1032	(2006; R 2012) Standard Specification for Woven Wire Plaster Base
ASTM C1063	(2012a) Standard Practice for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C206	(2003; R 2009) Standard Specification for Finishing Hydrated Lime
ASTM C841	(2003; E 2008; R 2008) Installation of Interior Lathing and Furring
ASTM C847	(2012) Standard Specification for Metal Lath
ASTM C897	(2005; R 2009) Aggregate for Job-Mixed Portland Cement-Based Plasters
ASTM C926	(2012) Application of Portland Cement-Based Plaster
ASTM C933	(2011) Welded Wire Lath
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2578	(2002) Fine Aggregates for Plaster
KS L 5201	(2013) Portland Cement

KS L 9007 (2006) Decorated Quicklime and Hydrated Lime

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lath

SD-03 Product Data

Proportions and Mixing

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver packaged materials to the site in the original packages and containers with labels intact and seals unbroken. Keep cementitious materials dry and stored off the ground, under cover and away from damp surfaces until ready to be used. Aggregate shall be covered to prevent the absorption or loss of moisture.

1.4 ENVIRONMENTAL REQUIREMENTS

Do not apply stucco when the ambient temperature is 4 degrees C (40 degrees F) or lower, or when a drop in temperature below 4 degrees C (40 degrees F) is expected within 48 hours after application.

PART 2 PRODUCTS

2.1 PORTLAND CEMENT

Portland cement shall conform to ASTM C150/C150M or KS L 5201, gray or white portland cement, Type I, II, or III.

2.2 COLORED STUCCO FINISH COAT

Colored stucco finish coat shall be a mill mixed product using white portland cement and requiring only the addition of and mixing with water for application. Color shall be as indicated. Submit samples including both a fabricated portion of unit of work and color samples.

2.3 LIME

Lime shall conform to ASTM C206, Type S, or KS L 9007.

2.4 SAND

Sand aggregate for job-mixed base coat and job-mixed finish coat stucco shall conform to ASTM C897 or KS F 2578.

2.5 ACCESSORIES

Accessories shall be roll formed galvanized steel, or rigid polyvinyl chloride (PVC), except that cornerite and striplath shall be formed from steel sheets with manufacturer's standard galvanized coating. Vinyl members shall be in accordance with ASTM D1784. Welded wire corner reinforcements shall be zinc coated, galvanized 1.4 mm (17 gauge) steel wire conforming to ASTM A185/A185M. Furring shall include hangers, bolts, inserts, clips, fastenings, and attachments of number, size, and design to develop the full strength of the members.

2.6 STEEL FRAMING

Steel framing shall be as shown and shall be manufacturers standard products with shop applied protective coating.

2.7 METAL LATH

Metal lath shall conform to ASTM C847, types and weights in accordance with the various spacing shown in ASTM C841. Lath for vertical application on steel and wood framing supports shall be expanded metal or welded or woven wire and shall have paper backing with a minimum vapor permeance of 287.2 ng per Pa per second per square meter (5 perms). Woven wire lath shall be a maximum 38 x 38 mm (1-1/2 x 1-1/2 inch) mesh wire of not less than 1.37 mm (0.0540 inch) nominal diameter and shall conform to ASTM C1032. Welded wire lath shall conform to ASTM C933, with openings not to exceed 50 x 50 mm (2 x 2 inches). Expanded metal or wire lath shall be fabricated in a manner to provide not less than 6 mm (1/4 inch) keying between wire and paper backing and keying shall be obtained by a uniform series of slots in a perforated face paper woven between the wires.

2.8 WATER

Provide clean, fresh, potable water, free from amounts of oils, acids, alkalis and organic matter that would be injurious to the stucco.

2.9 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 FRAMING

Framing shall be installed as indicated.

3.2 CONTROL JOINTS

Control joints shall be located as indicated on the drawings. Prefabricated control joint members shall be installed prior to the application of the stucco. Control joints shall be cleared of all stucco within the control area after stucco application and prior to final stucco set.

3.3 LATH

Install lath in accordance with ASTM C841 or ASTM C1063 except as otherwise specified. Metal and wire lath shall be applied straight, without buckles and with joints staggered. End laps of metal lath shall be not less than 25 mm (1 inch). When paper-backed lath is used, the paper shall be split from the lath at all lap areas to provide a paper to paper and lath to lath lap. Horizontal joints shall be shiplapped. Lath shall be interrupted at all control joints. Submit drawings showing details of construction for reinforcement, furring, and grounds; including manufacturer's installation instructions for stucco materials, and locations where each mix and coating thickness will be used.

3.3.1 Steel and Wood Supports

Apply metal lath over vertical open or solid wood and steel backing frame construction only after sheathing and air barrier has been applied to the area to receive the stucco. Fasten lath every 200 mm (8 inches) vertically and every 400 mm (16 inches) horizontally; and where sheets of lath are lapped. Drive fasteners to hold both lapped edges securely in place.

3.3.2 On Concrete and Masonry

Fasten lath every 200 mm (8 inches) vertically and every 400 mm (16 inches) horizontally. Where wood supports adjoin masonry or concrete in the same direction, provide casing bead, control joints, or reinforcement as indicated.

3.3.3 Over Metal Lintels and Flashings

Lath over metal lintels shall be extended vertically over the angles to a height of not less than 150 mm (6 inches) and horizontally across the underside of the lintels and shall be secured in an approved manner. Lath over metal flashings shall lap the flashings not less than 50 mm (2 inches) and shall be extended vertically for a height of not less than 150 mm (6 inches).

3.3.4 Special Shapes, Profiles, and Contours

Special shapes, profiles, and contours shall be formed with wood, metal or aluminum furring and reinforcing.

3.4 FURRING

Furring shall be installed to true lines and surfaces and shall be rigidly supported and secured in place.

3.5 PREPARATION OF SURFACES

Preparation of surfaces for application of stucco to solid bases such as stone, masonry or concrete shall conform to the applicable requirements of ASTM C926.

3.6 PROPORTIONS AND MIXING

Proportions and mixing for job-mixed base coat and finish coat shall conform to the applicable requirements of ASTM C926. Mixing of mill-mixed finish coat shall be in accordance with the manufacturer's directions. Submit detailed description of the proposed job-mix proportions for base and finish coats; including identification of thickness of coats.

3.7 STUCCO APPLICATION

Stucco shall be applied in three coats to a thickness of not less than 25 mm (1 inch) as measured from the back plane of metal reinforcement, exclusive of ribs or dimples or from the face of solid backing or support, with or without metal reinforcement, to the finished stucco surface, including moderate texture variations. Stucco application shall conform to the applicable requirements of ASTM C926 and the following:

3.7.1 Workmanship

Items or features of the work in connection with or adjoining the stucco shall be in place, plumb, straight, and true prior to beginning the stucco work. Metal and wire lath, where required, shall be in place and positioned to provide a good key at back of lath. Where lath is applied over copper, the copper shall be given a heavy coat of bituminous paint. Masonry surfaces to receive stucco shall be evenly dampened immediately prior to application of stucco. Each stucco coat shall be applied continuously in one general direction, without allowing mortar to dry at edges. Where it is impossible to work the full dimension of a wall surface in a continuous operation, jointing shall be made at a break, opening, or other natural division of the surface. Edges to be joined shall be dampened slightly to produce a smooth confluence. Exterior corners of stucco shall be slightly rounded. Stucco on soffit surfaces shall be pitched forward to form a drip.

3.7.2 Scratch Coat

Scratch coat shall be applied not less than 10 mm (3/8 inch) thick under sufficient pressure to form good keys and to completely embed the reinforcement. Before the scratch coat has set, it shall be lightly scratched in one direction and vertical surfaces shall be scratched in the horizontal direction only. The scratch coat shall be fog cured for a minimum of 72 hours.

3.7.3 Brown Coat

The scratch coat shall be dampened evenly to obtain uniform suction before the brown coat is applied. There shall be no visible water on the surface when the brown coat is applied. The brown coat shall be applied to the scratch coat with sufficient pressure to force the stucco into the scratches and shall be brought to a plumb, true, even plane with rod or straightedge. When set sufficiently, the brown coat shall be uniformly floated with a dry float to promote densification of the coat and to provide a surface receptive to bonding of the finish coat. Brown coat shall be fog cured for a minimum of 72 hours.

3.7.4 Finish Coat

Surfaces of the brown coat shall be dampened not more than 1 hour before the finish coat is to be applied to a uniform wetness with no free-standing water on the surface. The finish coat shall have a smooth trowel, float, trowel-textured, rough-textured, spray-textured, or exposed aggregate finish as indicated and shall conform to the approved sample. The finish coat shall be fog cured for a minimum of 48 hours. Care shall be taken to prevent staining.

3.7.5 Surface Tolerance

When a 3 m (10 foot) straightedge is placed at any location on the finished surface of the stucco, excluding rough-textured finish, the surface shall not vary more than 3 mm (1/8 inch) from the straightedge.

3.8 CURING AND PROTECTION

Perform fog curing by applying a fine mist of water to the stucco. Care shall be exercised during fog curing to avoid erosion damage of the stucco surfaces. Do not use a solid stream of water. Frequency of fogging shall be not less than three times daily. Protect the stucco from the direct rays of the sun during severe drying conditions using canvas, cloth or other approved sheet material, when directed.

3.9 PATCHING AND POINTING

Loose, cracked, damaged or defective work shall be replaced or patched as directed. Patching shall match existing work in texture and color and shall be finished flush.

-- End of Section --

SECTION 09 29 00

GYPSUM BOARD

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A108.11	(1992; Reaffirmed 2005) Specifications for Interior Installation of Cementitious Backer Units

ASTM INTERNATIONAL (ASTM)

ASTM C1002	(2007) Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
ASTM C1047	(2010a) Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base
ASTM C1177/C1177M	(2008) Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C1178/C1178M	(2011) Standard Specification for Glass Mat Water-Resistant Gypsum Backing Panel
ASTM C1396/C1396M	(2011) Standard Specification for Gypsum Board
ASTM C1629/C1629M	(2006; R 2011) Standard Classification for Abuse-Resistant Nondecorated Interior Gypsum Panel Products and Fiber-Reinforced Cement Panels
ASTM C475/C475M	(2002; R 2007) Joint Compound and Joint Tape for Finishing Gypsum Board
ASTM C514	(2004e1; R 2009) Standard Specification for Nails for the Application of Gypsum Board
ASTM C557	(2003; R 2009e1) Adhesives for Fastening Gypsum Wallboard to Wood Framing
ASTM C840	(2011) Application and Finishing of Gypsum Board

ASTM C954	(2011) Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness
ASTM D1037	(2006a) Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
ASTM D1149	(2007; R 2012) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D2394	(2005; R 2011) Simulated Service Testing of Wood and Wood-Base Finish Flooring
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D5420	(2010) Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Strike Impacted by a Falling Weight (Gardner Impact)
ASTM D624	(2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM E695	(2003; R 2009) Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

GYPSUM ASSOCIATION (GA)

GA 214	(2010) Recommended Levels of Gypsum Board Finish
GA 216	(2010) Application and Finishing of Gypsum Panel Products
GA 224	(2008) Installation of Predecorated Gypsum Board
GA 253	(2007) Application of Gypsum Sheathing
GA 600	(2009) Fire Resistance Design Manual

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1060	(2008) Self Drilling Tapping Screws

KS F 3504	(2007) Gypsum Boards
KS F 3514	(2001) Gypsum Board Nail
KS F 4901	(2012) Asphalt Roofing Felts (Fiber Base, Saturated Bitumen Felts)
KS F 4915	(2005) Joint Treatment Materials for Gypsum Boards
KS L 9203	(2006) Water Resistant Gypsum Backing Boards

UNDERWRITERS LABORATORIES (UL)

UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Gypsum Board

Cementitious backer units

Glass Mat Water-Resistant Gypsum Tile Backing Board

Water-Resistant Gypsum Backing Board

Glass Mat Covered or Reinforced Gypsum Sheathing

Glass Mat Covered or Reinforced Gypsum Sheathing Sealant

Impact Resistant Gypsum Board

Accessories

SD-07 Certificates

Asbestos Free Materials; G

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery

Deliver materials in the original packages, containers, or bundles with each bearing the brand name, applicable standard designation, and name of manufacturer, or supplier.

1.3.2 Storage

Keep materials dry by storing inside a sheltered building. Where necessary to store gypsum board and cementitious backer units outside, store off the ground, properly supported on a level platform, and protected from direct exposure to rain, snow, sunlight, and other extreme weather conditions. Provide adequate ventilation to prevent condensation. Store per manufacturer's recommendations for allowable temperature and humidity range. Do not store panels near materials that may emit harmful fumes, such as kerosene heaters, fresh paint, or adhesives.

1.3.3 Handling

Neatly stack gypsum board and cementitious backer units flat to prevent sagging or damage to the edges, ends, and surfaces.

1.4 ENVIRONMENTAL CONDITIONS

1.4.1 Temperature

Maintain a uniform temperature of not less than 10 degrees C (50 degrees F) in the structure for at least 48 hours prior to, during, and following the application of gypsum board, cementitious backer units, and joint treatment materials, or the bonding of adhesives.

1.4.2 Exposure to Weather

Protect gypsum board and cementitious backer unit products from direct exposure to rain, snow, sunlight, and other extreme weather conditions.

1.5 QUALIFICATIONS

Furnish type of gypsum board work specialized by the installer with a minimum of 3 years of documented successful experience.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to specifications, standards and requirements specified. Provide certification that gypsum board types, gypsum backing board types, cementitious backing units, and joint treating materials are manufactured from asbestos free materials only.

2.1.1 Gypsum Board

ASTM C1396/C1396M or KS F 3504.

2.1.1.1 Regular

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated. Provide tapered and featured edge gypsum board as indicated.

2.1.1.2 Foil-Backed

1200 mm (8 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, as indicated tapered and featured edges.

2.1.1.3 Type X (Special Fire-Resistant)

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, as indicated tapered and featured edges.

2.1.2 Gypsum Backing Board

ASTM C1396/C1396M, gypsum backing board shall be used as a base in a multilayer system.

2.1.2.1 Regular

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, square edges.

2.1.2.2 Foil-Backed

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, square edges.

2.1.2.3 Type X (Special Fire-Resistant)

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, as indicated, square edges.

2.1.3 Regular Water-Resistant Gypsum Backing Board

ASTM C1396/C1396M or KS L 9203.

2.1.3.1 Regular

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, tapered or square edges, as indicated.

2.1.3.2 Type X (Special Fire-Resistant)

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, tapered or square edges, as indicated.

2.1.4 Glass Mat Water-Resistant Gypsum Tile Backing Board

ASTM C1178/C1178M.

2.1.4.1 Regular

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, as indicated, square edges.

2.1.4.2 Type X (Special Fire-Resistant)

1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, as indicated, square edges.

2.1.5 Glass Mat Covered or Reinforced Gypsum Sheathing

Exceeds physical properties of ASTM C1396/C1396M and ASTM C1177/C1177M. Provide 12.7 mm (1/2 inch), gypsum sheathing unless otherwise indicated. Provide gypsum board of with a noncombustible water-resistant core, with glass mat surfaces embedded to the gypsum core or reinforcing embedded throughout the gypsum core. Warrant gypsum sheathing board for at least twelve months against delamination due to direct weather exposure. Provide continuous, asphalt impregnated, building felt to cover exterior face of sheathing. Seal all joints, seams, and penetrations with compatible sealant.

2.1.5.1 Glass Mat Covered or Reinforced Gypsum Sheathing Sealant

Provide sealant compatible with gypsum sheathing, rubber washers for masonry veneer anchors, and other associated cavity wall components such as anchors and through wall flashing. Provide sealants for gypsum sheathing board edge seams and veneer anchor penetrations recommended by the gypsum sheathing manufacturer and have the following performance requirements:

a. ASTM D412: Tensile Strength, 551 kPa (80 psi)
b. ASTM D412: Ultimate Tensile Strength (maximum elongation), 1172 kPa (170 psi)
c. ASTM D624: Tear Strength, dieB, 4.7 kN/m (27 ppi)
d. ASTM D1149: Joint Movement Capability after 14 Days cure, plus or minus 50 percent.

2.1.6 Impact Resistant Gypsum Board

1200 mm (48 inch) wide, 15.9 mm (5/8 inch) thick, tapered edges. Reinforced gypsum panel with imbedded fiber mesh or lexan backing testing in accordance with the following tests. Hard body impact test must attain a Level 2 performance in accordance with ASTM C1629/C1629M. Provide fasteners that meet manufacturer requirements and specifications stated within this section. Impact resistant gypsum board, when tested in accordance with ASTM E84, shall have a flame spread rating of 75 or less and a smoke developed rating of 100 or less, unless otherwise indicated.

2.1.6.1 Structural Failure Test

ASTM E695 or ASTM D2394 for structural failure (drop penetration). ASTM E695 using a 27.2 kg (60 lb) sand filled leather bag, resisting no less than 407 N-m (300 ft. lb.) cumulative impact energy before failure or ASTM D2394 using 139.7 mm (5.5 inch) hemispherical projectile resisting no less than 357 N-m (264 ft. lb.) before failure. Provide test specimen stud spacing a minimum 406 mm (16 inch) on center.

2.1.6.2 Indentation Test

ASTM D5420 or ASTM D1037 for indentation resistance. ASTM D5420 using a .907 kg (32 oz) weight with a 16 mm (5/8 inch) hemispherical impacting head dropped once 915 mm (3 feet) creating not more than 3.5 mm (0.137 inch) indentation or ASTM D1037 using no less than 213 kg (470 lb) weight applied to the 11.13 mm (0.438 inch) diameter ball to create not more than a 0.5 mm (0.0197 inch) indentation depth.

2.1.7 Predecorated Gypsum Board

ASTM C1396/C1396M, regular or Type X gypsum board as indicated, 1200 mm (48 inch) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick, with a decorative wall covering (Class I) or coating (Class II) applied in-plant by the gypsum board manufacturer. The color and pattern of wall covering shall be as indicated. Furnish predecorated gypsum board with a flame spread rating of 75 or less and a smoke developed rating of 100 or less, unless otherwise indicated.

2.1.8 Cementitious Backer Units

In accordance with the Tile Council of America (TCA) Handbook.

2.1.9 Joint Treatment Materials

ASTM C475/C475M or KS F 4915. Use all purpose joint and texturing compound containing inert fillers and natural binders, including lime compound. Pre-mixed compounds shall be free of antifreeze, vinyl adhesives, preservatives, biocides and other slow releasing compounds.

2.1.9.1 Embedding Compound

Specifically formulated and manufactured for use in embedding tape at gypsum board joints and compatible with tape, substrate and fasteners.

2.1.9.2 Finishing or Topping Compound

Specifically formulated and manufactured for use as a finishing compound.

2.1.9.3 All-Purpose Compound

Specifically formulated and manufactured to serve as both a taping and a finishing compound and compatible with tape, substrate and fasteners.

2.1.9.4 Setting or Hardening Type Compound

Specifically formulated and manufactured for use with fiber glass mesh tape.

2.1.9.5 Joint Tape

Use cross-laminated, tapered edge, reinforced paper, or fiber glass mesh tape recommended by the manufacturer.

2.1.10 Fasteners

2.1.10.1 Nails

ASTM C514 or KS F 3514. For predecorated gypsum board provide special nails with factory coated heads of color to match wall covering materials as recommended by the predecorated gypsum board manufacturer.

2.1.10.2 Screws

ASTM C1002, Type "G", Type "S" or Type "W" steel drill screws for fastening gypsum board to gypsum board, wood framing members and steel framing members less than 0.84 mm (0.033 inch) thick. ASTM C954 or KS B 1060 steel drill screws for fastening gypsum board to steel framing members 0.84 to 2.84 mm (0.033 to 0.112 inch) thick. Provide cementitious backer unit screws with a polymer coating.

2.1.10.3 Staples

1.5 mm thick (No. 16 USS gage)flattened galvanized wire staples with 11.1 mm (7/16 inch) wide crown outside measurement and divergent point for base ply of two-ply gypsum board application. Use as follows:

Length of Legs	Thickness of Gypsum Board
28.6 mm (1-1/8 inches)	12.7 mm (1/2 inch)
31.8 mm (1-1/4 inches)	15.9 mm (5/8 inch)

2.1.11 Adhesives

Do not use adhesive containing benzene, carbon tetrachloride, or trichloroethylene. Adhesive shall contain a maximum VOC content of 50 grams per liter.

2.1.11.1 Adhesive for Fastening Gypsum Board to Metal Framing

Not permitted.

2.1.11.2 Adhesive for Fastening Gypsum Board to Wood Framing

ASTM C557.

2.1.11.3 Adhesive for Laminating

Adhesive attachment is not permitted for multi-layer gypsum boards. For laminating gypsum studs to face panels, provide adhesive recommended by gypsum board manufacturer.

2.1.12 Gypsum Studs

Provide 25 mm (one inch) minimum thickness and 150 mm (6 inch) minimum width. Studs may be of 25 mm (one inch) thick gypsum board or multilayers fastened to required thickness. Conform to ASTM C1396/C1396M for material.

2.1.13 Shaftwall Liner Panel

ASTM C1396/C1396M. Conform to the UL Fire Resistance for the Design Numbers(s) indicated for shaftwall liner panels. Manufacture liner panel for cavity shaftwall system, with water-resistant paper faces, bevel edges, single lengths to fit required conditions, 25.4 mm (1 inch) thick, by 610 mm (24 inches) wide.

2.1.14 Accessories

ASTM C1047. Fabricate from corrosion protected steel or plastic designed for intended use. Accessories manufactured with paper flanges are not acceptable. Flanges shall be free of dirt, grease, and other materials that may adversely affect bond of joint treatment. Provide prefinished or job decorated materials. For predecorated gypsum board provide prefinished metal or plastic trim to match predecorated gypsum board.

2.1.15 Asphalt Impregnated Building Felt

Provide a 6.7 kg (15 lb) asphalt moisture barrier over gypsum sheathing. Conforming to ASTM D226/D226M Type 1 (No. 15) or KS F 4901 for asphalt impregnated building felt.

2.1.16 Water

Provide clean, fresh, and potable water.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Framing and Furring

Verify that framing and furring are securely attached and of sizes and spacing to provide a suitable substrate to receive gypsum board and cementitious backer units. Verify that all blocking, headers and supports are in place to support plumbing fixtures and to receive soap dishes, grab bars, towel racks, and similar items. Do not proceed with work until framing and furring are acceptable for application of gypsum board and cementitious backer units.

3.1.2 Gypsum Board and Framing

Verify that surfaces of gypsum board and framing to be bonded with an adhesive are free of dust, dirt, grease, and any other foreign matter. Do not proceed with work until surfaces are acceptable for application of gypsum board with adhesive.

3.1.3 Masonry and Concrete Walls

Verify that surfaces of masonry and concrete walls to receive gypsum board applied with adhesive are dry, free of dust, oil, form release agents, protrusions and voids, and any other foreign matter. Do not proceed with work until surfaces are acceptable for application of gypsum board with adhesive.

3.2 APPLICATION OF GYPSUM BOARD

Apply gypsum board to framing and furring members in accordance with ASTM C840 or GA 216 and the requirements specified. Apply gypsum board with separate panels in moderate contact; do not force in place. Stagger end joints of adjoining panels. Neatly fit abutting end and edge joints. Use gypsum board of maximum practical length; select panel sizes to minimize waste. Cut out gypsum board to make neat, close, and tight joints around openings. In vertical application of gypsum board, provide panels in lengths required to reach full height of vertical surfaces in one continuous piece. Lay out panels to minimize waste; reuse cutoffs whenever feasible. Surfaces of gypsum board and substrate members may be bonded together with an adhesive, except where prohibited by fire rating(s) or where prohibited elsewhere in this section. Treat edges of cutouts for plumbing pipes, screw heads, and joints with water-resistant compound as recommended by the gypsum board manufacturer. Provide type of gypsum board for use in each system specified herein as indicated.

3.2.1 Application of Single-Ply Gypsum Board to Wood Framing

Apply in accordance with ASTM C840, System I or GA 216.

3.2.2 Application of Two-Ply Gypsum Board to Wood Framing

Apply in accordance with ASTM C840, System II or GA 216.

3.2.3 Adhesive Nail-On Application to Wood Framing

Apply in accordance with ASTM C840, System III or GA 216. This method may be used in lieu of ASTM C840, System I at the option of the Contractor.

3.2.4 Semi-Solid Gypsum Board Partitions

Provide in accordance with ASTM C840, System IV or GA 216 .

3.2.5 Solid Gypsum Board Partitions

Provide in accordance with ASTM C840, System V or GA 216.

3.2.6 Adhesive Application to Interior Masonry or Concrete Walls

Apply in accordance with ASTM C840, System VI or GA 216.

3.2.7 Application of Gypsum Board to Steel Framing and Furring

Apply in accordance with ASTM C840, System VIII or GA 216.

3.2.8 Arches and Bending Radii

Apply gypsum board in accordance with ASTM C840, System IX or GA 216.

3.2.9 Gypsum Board for Wall Tile or Tile Base Applied with Adhesive

In dry areas (areas other than tubs, shower enclosures, saunas, steam rooms, gang shower rooms), apply glass mat water-resistant gypsum tile backing board or water-resistant gypsum backing board in accordance with ASTM C840, System X or GA 216.

3.2.10 Exterior Application

Apply exterior gypsum board (such as at soffits) in accordance with ASTM C840, System XI or GA 216.

3.2.11 Glass Mat Covered or Fiber Reinforced Gypsum Sheathing

Apply gypsum sheathing in accordance to gypsum association publications GA 253. Follow gypsum sheathing manufacturer's requirements of design details for joints and fasteners and be properly installed to protect the substrate from moisture intrusion. Do not leave exposed surfaces of the gypsum sheathing beyond the manufacturer's recommendation without a weather barrier cladding. Provide continuous asphalt impregnated building felt over sheathing surface in shingle fashion with edges and ends lapped a minimum of 150 mm (6 inch). Property flash the openings. Seal all joints, seams, and penetrations with a compatible silicone sealant.

3.2.12 Floating Interior Angles

Minimize framing by floating corners with single studs and drywall clips. Locate the attachment fasteners adjacent to ceiling and wall intersections in accordance with ASTM C840, System XII or GA 216, for single-ply and two-ply applications of gypsum board to wood framing.

3.2.13 Control Joints

Install expansion and contraction joints in ceilings and walls in accordance with ASTM C840, System XIII or GA 216. Fill control joints between studs in fire-rated construction with fireproofing insulation to match the fire-rating of construction.

3.2.14 Application of Foil-Backed Gypsum Board

Apply foil-backed gypsum board in accordance with ASTM C840, System XIV or GA 216.

3.2.15 Application of Predecorated Gypsum Board

Apply predecorated gypsum board in accordance with GA 224. Attach predecorated gypsum board with adhesive and fasteners as recommended by the manufacturer. Conceal fasteners in the finished work.

3.2.16 Application of Impact Resistant Gypsum Board

Apply in accordance with applicable system of ASTM C840 as specified or GA 216. Follow manufacturers written instructions on how to cut, drill and attach board.

3.3 APPLICATION OF CEMENTITIOUS BACKER UNITS

3.3.1 Application

In wet areas (tubs, shower enclosures, saunas, steam rooms, gang shower rooms), apply cementitious backer units in accordance with ANSI A108.11. Place a 7.6 kg (15 lb) asphalt impregnated, continuous felt paper membrane behind cementitious backer units, between backer units and studs or base layer of gypsum board. Place membrane with a minimum 150 mm (6 inch) overlap of sheets laid shingle style.

3.3.2 Joint Treatment

ANSI A108.11.

3.4 FINISHING OF GYPSUM BOARD

Tape and finish gypsum board in accordance with ASTM C840, GA 214 and GA 216. Finish plenum areas above ceilings to Level 1 in accordance with GA 214. Finish water resistant gypsum backing board, ASTM C1396/C1396M, to receive ceramic tile to Level 2 in accordance with GA 214. Finish walls and ceilings to receive a heavy-grade wall covering or heave textured finish before painting to Level 3 in accordance with GA 214. Finish walls and ceilings without critical lighting to receive flat paints, light textures, or wall coverings to Level 4 in accordance with GA 214. Unless otherwise specified, finish all gypsum board walls, partitions and ceilings to Level 5 in accordance with GA 214. Provide joint, fastener depression, and corner treatment. Tool joints as smoothly as possible to minimize sanding and dust. Do not use fiber glass mesh tape with conventional drying type joint compounds; use setting or hardening type compounds only. Provide treatment for water-resistant gypsum board as recommended by the gypsum board manufacturer. Protect workers, building occupants, and HVAC systems from gypsum dust.

3.4.1 Uniform Surface

Wherever gypsum board is to receive eggshell, semigloss or gloss paint finish, or where severe, up or down lighting conditions occur, finish gypsum wall surface in accordance to GA 214 Level 5. In accordance with GA 214 Level 5, apply a thin skim coat of joint compound to the entire gypsum board surface, after the two-coat joint and fastener treatment is complete and dry.

3.4.2 Metal Trim for Predecorated Gypsum Board

Finish edges, ends, and joints of predecorated gypsum board, except prefinished vee joints and monolithic type joints, with metal or plastic trim selected to match the gypsum board finish.

3.5 SEALING

Seal openings around pipes, fixtures, and other items projecting through gypsum board and cementitious backer units as specified in Section 07 92 00 JOINT SEALANTS Apply material with exposed surface flush with gypsum board or cementitious backer units.

3.5.1 Sealing for Glass Mat or Reinforced Gypsum Board Sheathing

Apply silicone sealant in a 9.5 mm (3/8 inch) bead to all joints and trowel flat. Apply enough of the same sealant to all fasteners penetrating through the glass mat gypsum board surface to completely cover the penetration when troweled flat. Do not place construction and materials behind sheathing until a visual inspection of sealed joints during daylight hours has been completed by Contracting Officer.

3.6 FIRE-RESISTANT ASSEMBLIES

Wherever fire-rated construction is indicated, provide materials and application methods, including types and spacing of fasteners, wall and ceiling framing in accordance with the specifications contained in UL Fire Resistance for the Design Number(s) indicated, or GA 600 for the File Number(s) indicated. Joints of fire-rated gypsum board enclosures shall be closed and sealed in accordance with UL test requirements or GA requirements. Seal penetrations through rated partitions and ceilings tight in accordance with tested systems.

3.7 PATCHING

Patch surface defects in gypsum board to a smooth, uniform appearance, ready to receive finishes. Remove predecorated gypsum board which cannot be restored to like-new condition. Provide new predecorated gypsum board.

3.8 SHAFTWALL FRAMING

Install the shaftwall system in accordance with the system manufacturer's published instructions. Coordinate bucks, anchors, blocking and other items placed in or behind shaftwall framing with electrical and mechanical work. Patch or replace fireproofing materials which are damaged or removed during shaftwall construction.

3.9 WASTE MANAGEMENT

As specified in Waste Management Plan.

-- End of Section --

SECTION 09 30 00

CERAMIC TILE, QUARRY TILE, AND PAVER TILE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM C1026	(2010) Standard Test Method for Measuring the Resistance of Ceramic Tile to Freeze-Thaw Cycling
ASTM C1027	(2009) Standard Test Method for Determining Visible Abrasion Resistance of Glazed Ceramic Tile
ASTM C1028	(2007e1) Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
ASTM C1178/C1178M	(2011) Standard Specification for Glass Mat Water-Resistant Gypsum Backing Panel
ASTM C144	(2011) Standard Specification for Aggregate for Masonry Mortar
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C206	(2003; R 2009) Standard Specification for Finishing Hydrated Lime
ASTM C207	(2006; R 2011) Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C241/C241M	(2009) Standard Specification for Abrasion Resistance of Stone Subjected to Foot Traffic
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C373	(1988; R 2006) Water Absorption, Bulk Density, Apparent Porosity, and Apparent

	Specific Gravity of Fired Whiteware Products
ASTM C482	(2002; R 2009) Bond Strength of Ceramic Tile to Portland Cement
ASTM C501	(1984; R 2009) Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
ASTM C648	(2004; R 2009) Breaking Strength of Ceramic Tile
ASTM C847	(2012) Standard Specification for Metal Lath
ASTM D2103	(2010) Standard Specification for Polyethylene Film and Sheeting
ASTM D226/D226M	(2009) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D4068	(2009) Chlorinated Polyethylene Sheeting for Concealed Water-Containment Membrane
ASTM F446	(1985; R 2009) Grab Bars and Accessories Installed in the Bathing Area

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2526	(2007) Aggregate for Concrete
KS L 1001	(2008) Ceramic Tiles
KS L 5204	(2007) White Portland Cement

MARBLE INSTITUTE OF AMERICA (MIA)

MIA Design Manual	(2003) Dimension Stone Design Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 99	(2015) Health Care Facilities Code

TILE COUNCIL OF NORTH AMERICA (TCNA)

TCA Hdbk	(2010) Handbook for Ceramic Tile Installation

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191	Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Tile; G
Setting-BedMortar, Grout, and Adhesive

SD-06 Test Reports

Testing; G

1.3 QUALITY ASSURANCE

Dimension and draw detail drawings at a minimum scale of 6 mm = 300 mm (1/4 inch = 1 foot). Include drawings of pattern at inside corners, outside corners, termination points and location of all equipment items such as thermostats, switch plates, mirrors and toilet accessories mounted on surface. Submit drawings showing ceramic tile pattern elevations and floor plans.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the project site in manufacturer's original unopened containers with seals unbroken and labels and hallmarks intact. Protect materials from weather, and store them under cover in accordance with manufacturer's printed instructions.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not perform ceramic tile work unless the substrate and ambient temperature is at least 10 degrees C (50 degrees F) and rising. Maintain temperature above 10 degrees C (50 degrees F) while the work is being performed and for at least 7 days after completion of the work. When temporary heaters are used, ventilate the area to the outside to avoid carbon dioxide damage to new tilework.

1.6 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a 1-year period.

1.7 EXTRA MATERIALS

Supply an extra two percent of each type tile used in clean and marked cartons.

PART 2 PRODUCTS

2.1 TILE

Conform to TCA Hdbk or KS L 1001 for standard grade tile. Provide grade sealed containers. Mark seals with the marks on the signed master grade certificate. Provide an impact resistant tile with a minimum floor breaking strength for wall tile of 41 kg (90 pound) and for floor tile of 113 kg (250 pound) in accordance with ASTM C648. The manufacturer will provide a frost resistant rating for tile used in cold climate projects as determined by ASTM C1026. Provide a 0.50 maximum percent water absorption in accordance with ASTM C373. Provide a minimum coefficient of friction of 0.50 wet and dry in accordance with ASTM C1028. Identify floor tile as Class III-Medium Heavy Traffic, durability classification as rated by the manufacturer when tested in accordance with ASTM C1027 for abrasion resistance as related to foot traffic. Coordinate the color with Contracting Officer Representative (COR) and facility user. Submit manufacturer's catalog data and preprinted installation and cleaning instructions plus a master grade certificate for tile.

2.1.1 Mosaic Tile

Provide tile size 25 by 25 mm (1 by 1 inch),25 by 50 mm (1 by 2 inch), or 50 by 50 mm(2 by 2 inch) as indicated. Coordinate color with Contracting Officer Representative (COR) and facility user.

2.1.2 Quarry Tile

Furnish an unglazed quarry tile and trim with abrasive surface. Use 150 by 150 by 13 mm (6 by 6 by 1/2 inch). Coordinate color with Contracting Officer Representative (COR) and facility user.

2.1.3 Paver Tile

Furnish 100 by 100 by 10 mm (4 by 4 by 3/8 inch) or 150 by 150 by 10 mm (6 by 6 by 3/8 inch) size paver tile made of low-fire clay, unglazed. Coordinate color with Contracting Officer Representative (COR) and facility user.

2.1.4 Detectable Warning Tile

Furnish an unglazed detectable warning tile with raised truncated domes with a diameter of nominal 23 mm (0.9 inch) at a height of nominal 5 mm (0.2 inch) and a center-to-center spacing of nominal 60 mm (2.35 inch) that contrast visually with adjoining surfaces. Provide 150 by 150 by 13 mm (6 by 6 by 1/2 inch) tile. Coordinate color with Contracting Officer Representative (COR) and facility user.

2.1.5 Porcelain Tile

Furnish an unglazed porcelain tile and trim with the color extending uniformly through the body of the tile. Provide a nominal size of 305 by 305 by 8 mm (12 by 12 by 5/16 inch) thick. Criteria for tile to meet or exceed is as follows: Abrasive wear in accordance with ASTM C501 and bonding strength in accordance with ASTM C482. Comply with 36 CFR 1191 for coefficient of friction for interior tiled floors. Coordinate color with Contracting Officer Representative (COR) and facility user.

2.1.6 Glazed Wall Tile

Provide glazed wall tile with cushioned edges and trim edged with lead-free bright or matte finish. Provide tile 106 by 106, 106 by 150, or 150 by 150 mm (4-1/4 by 4-1/4, 4-1/4 by 6, or 6 by 6 inch). Coordinate color with Contracting Officer Representative (COR) and facility user.

2.1.7 Accessories

Provide built-in type accessories of the same materials and finish as the wall tile. Provide accessories as follows in the quantities and locations indicated on contract drawings:

Recessed soap holders
Tumbler holders
Combination tumbler and toothbrush holders
Towel bars, stainless steel 600 mm (24 inches) long, two towel posts, unless otherwise indicated
Robe hooks
Roll paper holder
Recessed soap holder and hand hold combination: support static load in compliance with ASTM F446

2.2 SETTING-BED

Compose the setting-bed of the following materials:

2.2.1 Aggregate for Concrete Fill

Conform to ASTM C33/C33M or KS F 2526 for aggregate fill. Do not exceed one-half the thickness of concrete fill for maximum size of coarse aggregate.

2.2.2 Portland Cement

Conform to ASTM C150/C150M or KS L 5204 for cement, Type I, white for wall mortar and gray for other uses.

2.2.3 Sand

Conform to ASTM C144 for sand.

2.2.4 Hydrated Lime

Conform to ASTM C206 for hydrated lime, Type S or ASTM C207, Type S.

2.2.5 Metal Lath

Conform to ASTM C847 for flat expanded type metal lath, and weighing a minimum 1.4 kg/square meter (2.5 pound/square yard).

2.2.6 Reinforcing Wire Fabric

Conform to ASTM A185/A185M for wire fabric. Provide 50 by 50 mm (2 by 2 inch) mesh, 16/16 wire or 38 by 50 mm (1-1/2 by 2 inch) mesh, 16/13 wire.

2.3 WATER

Provide potable water.

2.4 MORTAR, GROUT, AND ADHESIVE

2.4.1 Dry-Set Portland Cement Mortar

TCA Hdbk.

2.4.2 Conductive Dry-Set Mortar

TCA Hdbk.

2.4.3 Latex-Portland Cement Mortar

TCA Hdbk.

2.4.4 Ceramic Tile Grout

TCA Hdbk; petroleum-free and plastic-free sand portland cement grout, dry-set grout, latex-portland cement grout, or commercial portland cement grout.

2.4.5 Organic Adhesive

TCA Hdbk, Type I. Water-resistant. Comply with applicable regulations regarding toxic and hazardous materials and as specified.

2.4.6 Epoxy Resin Grout

TCA Hdbk.

2.4.7 Furan Resin Grout

TCA Hdbk and consist of an intimate mixture of furfuryl-alcohol resin with carbon filler and catalyst.

2.4.8 Sealants

Comply with applicable regulations regarding toxic and hazardous materials and as specified.

2.4.9 Cementitious Backer Board

Provide cementitious backer units, for use as tile substrate over wood sub-floors, in accordance with TCA Hdbk. Furnish 12.7 mm (1/2 inch) thick cementitious backer units.

2.4.10 Glass Mat Gypsum Backer Panel

Provide glass mat water-resistant gypsum backer board, for use as tile substrate over wood subfloors, in accordance with ASTM C1178/C1178M. Provide 12.7 mm (1/2 inch) thick glass mat gypsum backer board.

2.5 MARBLE THRESHOLDS

Provide marble thresholds of size required by drawings or conditions. Categorize marble Group A as classified by MIA Design Manual. Provide a fine sand-rubbed finish marble with white in color as approved by the Contracting Officer. Provide minimum 12.0 marble abrasion when tested in accordance with ASTM C241/C241M.

2.6 MEMBRANE MATERIALS

Conform to ASTM D226/D226M, Type 1 for 33 kg (15 pound) waterproofing membrane, asphalt-saturated building felt. Conform to ASTM D2103 or ASTM D4068 0.0102 (4 mil) for polyethylene film.

2.7 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATORY WORK AND WORKMANSHIP

Inspect surface to receive tile in conformance to the requirements of TCA Hdbk for surface conditions for the type setting bed specified and for workmanship. Provide variations of tiled surfaces that fall within maximum values shown below:

TYPE	WALLS	FLOORS
Dry-Set Mortar	3 mm in 2.4 meters (1/8 inch in 8 feet)	3.0 mm in 3 meters (1/8 inch in 10 feet)
Organic Adhesives	3 mm in 2.4 meters (1/8 inch in 8 feet)	1.5 mm in 1 meters (1/16 inch in 3 feet)
Latex Portland Cement Mortar	3 mm in 2.4 meters (1/8 inch in 8 feet)	3.0 mm in 3 meters (1/8 inch in 10 feet)
Epoxy	3 mm in 2.4 meters (1/8 inch in 8 feet)	3.0 mm in 3 meters (1/8 inch in 10 feet)

3.2 GENERAL INSTALLATION REQUIREMENTS

Do not start tile work until roughing in for mechanical and electrical work has been completed and tested, and built-in items requiring membrane waterproofing have been installed and tested. Do not start floor tile installation in spaces requiring wall tile until after wall tile has been installed. Apply tile in colors and patterns indicated in the area shown on the drawings. Install tile with the respective surfaces in true even planes to the elevations and grades shown. Provide special shapes as required for sills, jambs, recesses, offsets, external corners, and other conditions to provide a complete and neatly finished installation. Solidly back tile bases and coves with mortar.

3.3 INSTALLATION OF WALL TILE

Install wall tile in accordance with the TCA Hdbk.

3.3.1 Workable or Cured Mortar Bed

Install tile over workable mortar bed or a cured mortar bed at the option of the Contractor. Install a 0.102 mm (4 mil) polyethylene membrane, metal lath, and scratch coat. Conform to TCA Hdbk for workable mortar bed, materials, and installation of tile. Conform to TCA Hdbk for cured mortar bed and materials.

3.3.2 Dry-Set Mortar and Latex-Portland Cement Mortar

Use Dry-set or Latex-Portland Cement to install tile in accordance with TCA Hdbk. Use Latex Portland Cement when installing porcelain ceramic tile.

3.3.3 Organic Adhesive

Conform to TCA Hdbk for the organic adhesive installation of ceramic tile.

3.3.4 Furan Mortar and Grout

Conform to TCA Hdbk for furan mortar and grout installation.

3.4 INSTALLATION OF FLOOR TILE

Install floor tile in accordance with TCA Hdbk. Install shower receptors in accordance with TCA Hdbk method B414 or B415.

3.4.1 Workable or Cured Mortar Bed

Install floor tile over a workable mortar bed or a cured mortar bed at the option of the Contractor. Conform to TCA Hdbk for workable mortar bed materials and installation. Conform to TCA Hdbk for cured mortar bed materials and installation. Provide minimum 6.35 mm (1/4 inch) to maximum 9.53 mm (3/8 inch joints in uniformed width).

3.4.2 Dry-Set and Latex-Portland Cement

Use dry-set or Latex-Portland cement mortar to install tile directly over properly cured, plane, clean concrete slabs in accordance with TCA Hdbk. Use Latex Portland cement when installing porcelain ceramic tile.

3.4.3 Resinous Grout

When resinous grout is indicated, grout quarry tile with either furan or epoxy resin grout. Rake and clean joints to the full depth of the tile and neutralize when recommended by the resin manufacturer. Install epoxy resin grout in conformance with TCA Hdbk. Install resin grout in accordance with manufacturer's printed installation instructions. Provide a coating of wax applied from the manufacturer on all tile installed and furan resin. Follow manufacturer's printed installation instructions of installed resin grout for proportioning, mixing, installing, and curing. Maintain the recommended temperature in the area and on the surface to be grouted. Protect finished grout of grout stain.

3.4.4 Ceramic Tile Grout

Prepare and install ceramic tile grout in accordance with TCA Hdbk.

3.4.5 Waterproofing

Shower pans are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Conform to the requirements of Section 07 12 00 BUILT-UP BITUMINOUS WATERPROOFING for waterproofing under concrete fill.

3.4.6 Concrete Fill

Provide a 24.1 MPa (3500 psi) concrete fill mix to dry as consistency as practicable. Compose concrete fill by volume of 1 part Portland cement to 3 parts fine aggregate to 4 parts coarse aggregate, and mix with water to as dry a consistency as practicable. Spread, tamp, and screed concrete fill to a true plane, and pitch to drains or levels as shown. Thoroughly damp concrete fill before applying setting-bed material. Reinforce concrete fill with one layer of reinforcement, with the uncut edges lapped the width of one mesh and the cut ends and edges lapped a minimum 50 mm (2 inch). Tie laps together with 1.3 mm (18 gauge) wire every 250 mm (10 inch) along the finished edges and every 150 mm (6 inch) along the cut ends and edges. Provide reinforcement with support and secure in the centers of concrete fills. Provide a continuous mesh; except where expansion joints occur, cut mesh and discontinue across such joints. Provide reinforced concrete fill under the setting-bed where the distance between the under-floor surface and the finished tiles floor surface is a minimum of 50 mm (2 inches), and of the same thickness that the mortar setting-bed over the concrete fill with the thickness required in the specified TCA Hdbk method.

3.5 INSTALLATION OF CONDUCTIVE FLOORING

Install conductive ceramic mosaic tile floors in accordance with TCA Hdbk.

3.6 INSTALLATION OF MARBLE THRESHOLDS

Install thresholds where indicated, in a manner similar to that of the ceramic tile floor. Provide thresholds full width of the opening. Install head joints at ends not exceeding 6 mm (1/4 inch) in width and grouted full.

3.7 TESTING

Perform electrical resistance tests on conductive flooring, in the presence of the Contracting Officer, by a technician experienced in such work. Furnish a copy of the test results. Provide test procedures, testing apparatus, and test results in accordance with the provisions for Conductive Flooring in NFPA 99.

3.8 EXPANSION JOINTS

Form and seal joints as specified in Section 07 92 00 JOINT SEALANTS.

3.8.1 Walls

Provide expansion joints at control joints in backing material. Wherever backing material changes, install an expansion joint to separate the different materials.

3.8.2 Floors

Provide expansion joints over construction joints, control joints, and expansion joints in concrete slabs. Provide expansion joints where tile abuts restraining surfaces such as perimeter walls, curbs and columns and at intervals of 7.2 to 10.8 m (24 to 36 feet) each way in large interior floor areas and 3.6 to 4.8 m (12 to 16 feet) each way in large exterior areas or areas exposed to direct sunlight or moisture. Extend expansion joints through setting-beds and fill.

3.9 CLEANING AND PROTECTING

Upon completion, thoroughly clean tile surfaces in accordance with manufacturer's approved cleaning instructions. Do not use acid for cleaning glazed tile. Clean floor tile with resinous grout or with factory mixed grout in accordance with printed instructions of the grout manufacturer. After the grout has set, provide a protective coat of a noncorrosive soap or other approved method of protection for tile wall surfaces. Cover tiled floor areas with building paper before foot traffic is permitted over the finished tile floors. Provide board walkways on tiled floors that are to be continuously used as passageways by workmen. Replace damaged or defective tiles.

3.10 WASTE MANAGEMENT

Separate waste, including metal and cardboard, in accordance with the Waste Management Plan and recycle or reuse. Place materials defined as hazardous or toxic waste, including used sealant and adhesive tubes and containers, in designated containers and areas. Close and seal tightly partly used sealant and adhesive containers and store in protected, well-ventilated, fire-safe area at moderate temperature. Place materials defined as hazardous or toxic waste, including used sealant and adhesive tubes and containers, in designated containers and areas and dispose of properly.

-- End of Section --

SECTION 09 51 00

ACOUSTICAL CEILINGS
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A489	(2004e1) Standard Specification for Carbon Steel Lifting Eyes
ASTM A641/A641M	(2009a; R 2014) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B633	(2013) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM C423	(2009a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM C635/C635M	(2007) Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings
ASTM C636/C636M	(2008) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM C834	(2010) Latex Sealants
ASTM E119	(2012a) Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E1264	(2008e1) Acoustical Ceiling Products
ASTM E1414/E1414M	(2011a) Airborne Sound Attenuation Between

	Rooms Sharing a Common Ceiling Plenum
ASTM E580/E580M	(2014) Application of Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels in Areas Requiring Moderate Seismic Restraint
ASTM E795	(2005) Mounting Test Specimens During Sound Absorption Tests
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3552	(2008) Low Carbon Steel Wires
KS L 9105	(2009) Dressed Mineral Wool Boards for Acoustical Use

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

Provide sound controlling units mechanically mounted on a ceiling suspension system for acoustical treatment. The unit size, texture, finish, and color must be as specified. The Contractor has the option to substitute inch-pound (I-P) Recessed Light Fixtures (RLF) for metric RLF. If the Contractor opts to furnish I-P RLF, other ceiling elements like acoustical ceiling tiles, air diffusers, air registers and grills, shall also be I-P products. Coordinate the whole ceiling system with other details, like the location of access panels and ceiling penetrations, etc., shown on the drawings. The Contractor is responsible for all associated labor and materials and for the final assembly and performance of the specified work and products if I-P products are used. The location and extent of acoustical treatment shall be as shown on the approved detail drawings. Submit drawings showing suspension system, method of anchoring and fastening, details, and reflected ceiling plan. Coordinate with paragraph RECLAMATION PROCEDURES for reclamation of mineral fiber acoustical ceiling panels to be removed from the job site.

1.2.1 Fire Resistive Ceilings

Rate acoustical ceiling systems, indicated as fire resistant, for fire endurance as specified when tested in accordance with ASTM E119. Test suspended ceiling with a specimen of roof and floor assemblies representative of the indicated construction, including mechanical and electrical work within ceiling space openings for light fixtures, and air outlets, and access panels. Provide ceiling assembly rating as shown on drawings. Provide acoustical units with a flame spread of 25 or less and smoke development of 50 or less when tested in accordance with ASTM E84.

1.2.2 Ceiling Attenuation Class and Test

Provide a ceiling system with an attenuation class (CAC) as indicated when determined in accordance with ASTM E1414/E1414M. Provide fixture attenuators over light fixtures and other ceiling penetrations, and provide acoustical blanket insulation adjacent to partitions, as required to achieve the specified CAC. Provide test ceiling continuous at the partition and assembled in the suspension system in the same manner that the ceiling will be installed on the project.

1.2.3 Ceiling Sound Absorption

Determine the Noise Reduction Coefficient (NRC) in accordance with ASTM C423 Test Method.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings

SD-03 Product Data

Acoustical Units

SD-06 Test Reports

Fire Resistive Ceilings
Ceiling Attenuation Class and Test

1.4 DELIVERY, STORAGE. AND HANDLING

Deliver materials to the site in the manufacturer's original unopened containers with brand name and type clearly marked. Carefully handle and store materials in dry, watertight enclosures. Immediately before installation, store acoustical units for not less than 24 hours at the same temperature and relative humidity as the space where they will be installed in order to assure proper temperature and moisture acclimation.

1.5 ENVIRONMENTAL REQUIREMENTS

Maintain a uniform temperature of not less than 16 degrees C (60 degrees F) nor more than 29 degrees C (85 degrees F) and a relative humidity of not more than 70 percent for 24 hours before, during, and 24 hours after installation of acoustical units.

1.6 SCHEDULING

Complete and dry interior finish work such as plastering, concrete and terrazzo work before ceiling installation. Complete mechanical, electrical, and other work above the ceiling line; install and start operating heating, ventilating, and air conditioning systems in order to maintain temperature and humidity requirements.

1.7 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a one year period. Include an agreement to repair or replace acoustical panels that fail within the warranty period in the standard performance guarantee or warranty. Failures include, but are not limited to, sagging and warping of panels; rusting and manufacturers defects of grid system.

1.8 EXTRA MATERIALS

Furnish spare tiles, from the same lot as those installed, of each color at the rate of 5 tiles for each 1000 tiles installed.

PART 2 PRODUCTS

2.1 ACOUSTICAL UNITS

Submit product data of each type of acoustical unit and each type of suspension grid tee section showing texture, finish, and color. Conform acoustical units to ASTM E1264, Class A, or KS L 9105 and the following requirements:

2.1.1 Units for Exposed-Grid System

a. Type: I (cellulose composition), III (non-asbestos mineral fiber with painted finish), IV (non-asbestos mineral fiber with membrane-faced overlay), IX (mineral fiber with scrubbable finish), X (mineral composition with plastic membrane), XI (mineral fiber with fabric faced overlay), or XII (fiberglass base with membrane-faced overlay), as indicated.

b. Flame Spread: Class A, 25 or less

c. Pattern: A, B, C, D, or F.

d. Minimum NRC: 0.75 in open office areas; 0.60 in conference rooms, executive offices, teleconferencing rooms, and other rooms as designated; 0.50 in all other rooms and areas when tested on mounting Type E-400 of ASTM E795.

e. Minimum Light Reflectance Coefficient: LR-1, 0.75 or greater.

f. Nominal size: 600 by 1200 mm (24 by 48 inches)

g. Edge detail: Square, Reveal, or Trimmed and butt.

h. Finish: Factory-applied standard finish.

i. Minimum CAC: 40.

2.1.2 Units for Concealed-Grid System

a. Type: I (cellulose composition), III (non-asbestos mineral fiber with painted finish), IV (non-asbestos mineral fiber with membrane-faced overlay), IX (mineral fiber with scrubbable finish), X (mineral composition with plastic membrane), XI (mineral fiber with fabric faced overlay), or XII (fiberglass base with membrane-faced overlay).

b. Flame Spread: Class A, 25 or less.

c. Pattern: A, B, C, D, E, F, or G.

d. Minimum NRC: 0.50 when tested on mounting Type B or Type E-400 of ASTM E795.

e. Minimum Light Reflectance Coefficient: LR-1, 0.75 or greater.

f. Nominal size: 300 by 300 mm (12 by 12 inches).

g. Edge detail: beveled or square.

h. Joint detail: kerfed and rabbeted or tongue and grooved.

i. Finish: Factory-applied standard finish.

j. Minimum CAC: 40.

2.1.3 Impact/Abrasion Resistant Units

a. Type: Non-asbestos mineral composition with a hardened mineral surface and factory applied white paint finish. Provide a surface resistant to impact and abrasion.

b. Flame Spread: Class: A, 25 or less.

c. Pattern: as indicated.

d. Minimum NRC: 0.50 when tested on Mounting Type E-400 of ASTM E795.

e. Minimum Light Reflectance Coefficient: LR-1, 0.75 or greater.

f. Nominal Size: 300 by 300 mm, 600 by 600 mm, or 600 by 1200 mm (12 by 12 inches, 24 by 24 inches, or 24 by 48 inches) as designed.

g. Edge Detail: Square or Beveled.

h. Joint Detail: Trimmed and butted or Kerfed and rabbeted.

2.1.4 Humidity Resistant Composition Units

a. Type: Non-asbestos mineral or glass fibers bonded with ceramic, moisture resistant thermo-setting resin, or other moisture resistant material and having a factory applied white paint finish. Provide panels that do not sag or warp under conditions of heat, high humidity or chemical fumes.

b. Flame Spread: Class: A, 25 or less.

d. Minimum NRC: Minimum 0.50 when tested on Mounting Type E-400 of ASTM E795.

e. Minimum Light Reflectance Coefficient: LR-1, 0.75 or greater.

f. Nominal Size: 600 mm by 1200 mm (24 inches by 48 inches).

g. Edge Detail: Square.

2.1.5 Metal Faced Composition Units

a. Type V (Steel facings with non-asbestos mineral composition absorbent backing).

b. Type VI (Stainless steel facings with non-asbestos mineral composition absorbent backing).

c. Type VII (Aluminum facings with non-asbestos mineral composition absorbent backing) with anodized, baked enamel, or acrylic finish color white.

d. Flame Spread: Class: A, flame spread 25 or less.

f. Minimum (NRC): 0.75 in open office areas. 0.60 in conference rooms, executive offices, teleconferencing rooms, and other rooms as designated. 0.50 in all other rooms and areas. Base the tested NRC value on Mounting Type E-400 of ASTM E795.

g. Minimum Light Reflectance Coefficient: LR-1, 0.75 or greater.

h. Nominal Size: 600 mm by 600 or 1200 mm (24 inches by 24 or 48 inches).

i. Edge Detail: Square.

j. Joint Detail: Trimmed and butted.

2.1.6 Unit Acoustical Absorbers

Absorbers shall be individually mounted sound absorbing plaques composed of glass fibers or non-asbestos mineral fibers and having a NRC range of not less than 0.60 - 0.70 when tested in accordance with ASTM C423 and reported as a 4 frequency average.

2.2 SUSPENSION SYSTEM

Provide standard direct hung, concealed, upward access standard width flange suspension system conforming to ASTM C635/C635M, unless otherwise indicated. Provide surfaces exposed to view of aluminum or steel with a factory-applied baked-enamel finish or aluminum with a clear anodized finish. Provide wall molding having a flange of not less than 23 mm (15/16 inch). Provide standard corners. Suspended ceiling framing system must have the capability to support the finished ceiling, light fixtures, air diffusers, and accessories, as shown. Provide a suspension system with a maximum deflection of 1/360 of the span length. Conform seismic details to the guidance in UFC 3-310-04 and ASTM E580/E580M.

2.3 HANGERS

Provide hangers and attachment capable of supporting a minimum 1330 N (300 pound) ultimate vertical load without failure of supporting material or attachment.

2.3.1 Wires

Conform wires to ASTM A641/A641M, Class 1, or KS D 3552, 2.7 mm (0.11 inch) in diameter, unless otherwise indicated.

2.3.2 Straps

Provide straps of 25 mm by 5 mm (1 by 3/16 inch) galvanized steel conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008Mwith an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.3.3 Rods

Provide 5 mm (3/16 inch) diameter threaded steel rods, zinc or cadmium coated.

2.3.4 Eyebolts

Provide eyebolts of weldless, forged-carbon-steel, with a straight-shank in accordance with ASTM A489. Eyebolt size must be a minimum 7 mm (1/4 inch), zinc coated.

2.3.5 Masonry Anchorage Devices

Comply with ASTM C636/C636M.

2.4 ACCESS PANELS

Provide access panels that match adjacent acoustical units, designed and equipped with suitable framing and fastenings for removal and replacement without damage. Size panel to be not less than 300 by 300 mm (12 by 12 inches) or more than 300 by 600 mm (12 by 24 inches).

a. Attach an identification plate of 0.8 mm (0.032 inch) thick aluminum, 19 mm (3/4 inch) in diameter, stamped with the letters "AP" and finished the same as the unit, near one corner on the face of each access panel.

b. Identify ceiling access panel by a number utilizing white identification plates or plastic buttons with contrasting numerals. Provide plates or buttons of minimum 25 mm (1 inch) diameter and securely attached to one corner of each access unit. Provide a typewritten card framed under glass listing the code identification numbers and corresponding system descriptions listed above. Mount the framed card where directed and furnish a duplicate card to the Contracting Officer. Code identification system is as follows:

1 Fire detection/alarm system

2 Air conditioning controls

3 Plumbing system

4 Heating and steam systems

5 Air conditioning duct system

6 Sprinkler system

7 Intercommunication system

8 Nurse's call system

9 Pneumatic tube system

10 Medical piping system

11 Program entertainment

12 Telephone junction boxes

13 Detector X-ray

2.5 ADHESIVE

Use adhesive as recommended by tile manufacturer.

2.6 FINISHES

Use manufacturer's standard textures, patterns and finishes as specified for acoustical units and suspension system members. Treat ceiling suspension system components to inhibit corrosion.

2.7 COLORS AND PATTERNS

Use colors and patterns for acoustical units and suspension system components as determined in coordination with Contracting Officer Representative (COR) and facility user.

2.8 ACOUSTICAL SEALANT

Conform acoustical sealant to ASTM C834, nonstaining.

2.9 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Examine surfaces to receive directly attached acoustical units for unevenness, irregularities, and dampness that would affect quality and execution of the work. Rid areas, where acoustical units will be cemented, of oils, form residue, or other materials that reduce bonding capabilities of the adhesive. Complete and dry interior finish work such as plastering, concrete, and terrazzo work before installation. Complete and approve mechanical, electrical, and other work above the ceiling line prior to the start of acoustical ceiling installation. Provide acoustical work complete with necessary fastenings, clips, and other accessories required for a complete installation. Do not expose mechanical fastenings in the finished work. Lay out hangers for each individual room or space. Provide hangers to support framing around beams, ducts, columns, grilles, and other penetrations through ceilings. Keep main runners and carrying channels clear of abutting walls and partitions. Provide at least two main runners for each ceiling span. Wherever required to bypass an object with the hanger wires, install a subsuspension system so that all hanger wires will be plumb.

3.1.1 Suspension System

Install suspension system in accordance with ASTM C636/C636M and as specified herein. Do not suspend hanger wires or other loads from underside of steel decking.

3.1.1.1 Plumb Hangers

Install hangers plumb and not pressing against insulation covering ducts and pipes. Where lighting fixtures are supported from the suspended ceiling system, provide hangers at a minimum of four hangers per fixture and located not more than 150 mm (6 inches) from each corner of each fixture.

3.1.1.2 Splayed Hangers

Where hangers must be splayed (sloped or slanted) around obstructions, offset the resulting horizontal force by bracing, countersplaying, or other acceptable means.

3.1.2 Wall Molding

Provide wall molding where ceilings abut vertical surfaces. Miter corners where wall moldings intersect or install corner caps. Secure wall molding not more than 75 mm (3 inches) from ends of each length and not more than 400 mm (16 inches) on centers between end fastenings. Provide wall molding springs at each acoustical unit in semi-exposed or concealed systems.

3.1.3 Acoustical Units

Install acoustical units in accordance with the approved installation instructions of the manufacturer. Ensure that edges of acoustical units are in close contact with metal supports, with each other, and in true alignment. Arrange acoustical units so that units less than one-half width are minimized. Hold units in exposed-grid system in place with manufacturer's standard hold-down clips, if units weigh less than 5 kg/square meter (1 psf) or if required for fire resistance rating.

3.1.4 Caulking

Seal all joints around pipes, ducts or electrical outlets penetrating the ceiling. Apply a continuous ribbon of acoustical sealant on vertical web of wall or edge moldings.

3.1.5 Adhesive Application

Wipe back of tile to remove accumulated dust. Daub acoustical units on back side with four equal daubs of adhesive. Apply daubs near corners of tiles. Ensure that contact area of each daub is at least 50 mm (2 inches) diameter in final position. Press units into place, aligning joints and abutting units tight and uniform without differences in joint widths.

3.2 CEILING ACCESS PANELS

Locate ceiling access panels directly under the items which require access.

3.3 CLEANING

Following installation, clean dirty or discolored surfaces of acoustical units and leave them free from defects. Remove units that are damaged or improperly installed and provide new units as directed.

3.4 RECLAMATION PROCEDURES

Neatly stack ceiling tile, designated for recycling by the Contracting Officer, on 1220 mm by 1220 mm (4 foot by 4 foot) pallets not higher than 1220 mm (4 feet). Panels must be completely dry. Shrink wrap and symmetrically stack pallets on top of each other without falling over.

-- End of Section --

SECTION 09 64 29

WOOD STRIP FLOORING
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

MAPLE FLOORING MANUFACTURERS ASSOCIATION (MFMA)

MFMA GS	(1999) Guide Specifications for Maple Flooring Systems

NATIONAL WOOD FLOORING ASSOCIATION (NWFA) (formerly NOFMA)

NOFMA Grading Rules	(1999) Official Flooring Grading Rules

1.2 SYSTEM DESCRIPTION

This specification is written to allow the Contractor to build wood strip floorings for gymnasiums, handball and squash courts, and other special purpose applications but does not preclude the installation of competitive, manufacturer standard, integrated systems.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Squash and Handball Court Walls; G

SD-03 Product Data

Bamboo
Installation

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site in original unopened packages, bundles or containers and with all labels intact. Store flooring in fully covered, well ventilated areas protected from extreme changes in temperature and humidity. Flooring shall be maintained at an average moisture content of 6 to 9 percent. Temperature and humidity in the storage area shall closely approximate the temperature and humidity of the rooms in which the flooring is to be installed.

1.5 ENVIRONMENTAL REQUIREMENTS

Provide permanent heating and air conditioning, installed and working, in rooms where wood flooring is to be installed or adequate arrangements for ventilation and temperature controls. The temperature shall be maintained at 14 to 27 degrees C (55 to 80 degrees F) and the humidity shall be maintained at 40 percent starting not less than 3 days prior to beginning the installation of flooring and continuing throughout the remainder of the contract period.

1.6 SCHEDULING

Strip flooring work shall be scheduled after any other work which would raise the moisture content of the flooring or damage the finished surface of the flooring.

PART 2 PRODUCTS

2.1 STRIP FLOORING

2.1.1 General Requirements

Strip flooring shall be 19 or 26 mm (3/4 or 1-1/32 inch) thick by 55 mm (2-1/4 inches) face width, kiln dried, continuous tongue and groove and of standard lengths. Beech and birch shall be second grade in accordance with NOFMA Grading Rules. Hard maple shall be second and better in accordance with MFMA GS. Red and white oak shall be select grade in accordance with NOFMA Grading Rules. Strip flooring shall be marked with the trademark of the grading agency. Submit two samples of each type of strip flooring.

2.1.2 Bamboo

Bamboo flooring shall be laminated, tongue-and-groove plank flooring, 16 to 19 mm (5/8 to 3/4 inch) thick, 2- or 3-ply, flat grain with horizontal laminations 2.2 NAILS

Provide nails in accordance with strip flooring manufacturer's recommendations.

2.3 RESILIENT PADS

Resilient pads shall be pneumatic rubber, PVC, or polyurethane resilient mounts to fit the selected floor system.

2.4 WALL BASE

Wall base shall be wood molding or vented cove with premolded outside corners and mitered inside corners.

2.5 MOISTURE BARRIER

Moisture barrier shall be 0.15 mm (6 mil) minimum thickness polyethylene.

2.6 CLIPS, ANCHOR CHANNELS AND INSULATION

Galvanized steel clips for steel channel anchorage systems shall be in accordance with steel channel anchorage system manufacturer's recommendations. Clips shall be designed to provide holding at least equal to the nailing specified and shall function without splitting the assembled boards or otherwise reducing the performance of the floor. Anchor channels shall be as recommended by the flooring manufacturer. Anchor channels shall be galvanized, complete with all pads, anchors and other components required for channel installation. Underfloor insulation shall be asphalt impregnated fiberboard or closed-cell polyethylene foam.

2.7 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

Concrete slab shall be level, steel troweled to a tolerance of 3 mm (1/8 inch)plus or minus in a 3 m (10 foot) radius. Slab surface shall be clean, dry, and approved prior to start of installation. The slab shall be depressed as required by the floor specified.

3.2 INSTALLATION

Install flooring in accordance with the approved installation instructions of the manufacturer. Submit manufacturer's descriptive data and installation instructions. Wood nailers are specified in Section 06 10 00 ROUGH CARPENTRY. Unless otherwise approved, flooring shall be laid parallel to the length of the area to be floored. Strips shall be laid to allow for intermediate expansion in accordance with humidity conditions expected during the life of the of the flooring. End joints shall be so alternated that there will be at least two boards between end joints in the same plane and at least 150 mm (6 inches) between end joints in adjacent boards. Space for expansion shall be left along perimeter walls and around fixed projections through the floor surface. Unless otherwise shown or permitted by the approved installation instructions, expansion space shall be 5 mm per meter (1/16 inch per foot) of distance between opposite walls, with one half the space provided at each wall and with a minimum space of 25 mm (1 inch) at each wall.

3.2.1 Gymnasium Floors

3.2.1.1 Wood Sleepers

For wood sleeper supported floors, the slab shall be vapor-sealed with a two-ply membrane and hot-poured, steep-slope asphalt to a minimum depth of 6 mm (1/4 inch) above bottom of sleepers. Anchored, treated wood sleepers shall be spaced at 400 mm (16 inches) on center with wood or plywood subfloor or, if required by design considerations, wood sleepers at 300 mm (12 inches) on centers without subfloor and with 26 mm (1-1/32 inch) thick flooring. Space between rows of wood sleepers shall be left vacant. Expansion joints shall be 50 mm (2 inches) maximum.

3.2.1.2 Steel Channels

Galvanized steel channel system shall be placed on manufacturer's standard grooved foam or grooved resilient insulation board. Expansion joints shall be in accordance with manufacturer's recommendations.

3.2.2 Squash and Handball Court Walls

Maximum space for expansion shall be 50 mm (2 inches) at each wall. Expansion joints over 25 mm (1 inch) and expansion joints for steel channel-strip flooring application shall be detailed and the drawings, showing the method of covering, submitted for approval.

3.2.2.1 Wood Supports

Anchored wood supports shall be used to keep the treated wood sleepers shimmed away from the wall to provide ventilation. Wood sleepers shall be spaced at 400 mm (16 inches) on center. Exterior grade plywood 15 mm (5/8 inch) thick, with two coats of aluminum enamel on the back side in accordance with Section 06 10 00 ROUGH CARPENTRY, shall be used for vapor seal and sound deadener.

3.2.2.2 Steel Supports

Anchored, galvanized, steel channel supports shall be used with steel channel system; steel channels shall be spaced at 300 mm (12 inches) on center. The space between the supporting wall and the back of the finished wall shall be filled to within 300 mm (12 inches) of the ceiling with an approved hot-poured, steep-slope asphalt as the construction of the wall progresses. As an option to the asphalt-backed wall construction when 26 mm (33/32 inch) thick flooring is used, the wall shall be vapor sealed with a 0.15 mm (6 mil) thickness of polyethylene sheeting prior to application to steel channels and the space between the supporting wall and the back of the finished wall shall be filled with insulation as used for the floor.

3.3 SANDING

Sand flooring to a smooth, even, uniform finish without burns. A minimum of three sanding cuts, each with a finer sandpaper, shall be made. Use a heavy drum-type sander for floors, except a disc-type sander is permitted for the final cut on strip flooring. Either the first pass or the second pass of the drum-type sander shall be at an angle of 45 degrees to the grain; other passes of the drum-type sander shall be in the direction of the grain of strip flooring. Finish edges not reached by the sander with an edger or by hand methods. Perform the final sanding at a time and in a manner that will permit application of the first seal coat as specified in Section 09 90 00 PAINTS AND COATINGS to be completed within 8 hours after completion of sanding. Leave the flooring clean and ready to receive the finishing materials.

3.4 PROTECTION

Protect flooring from damage from the time of installation until final acceptance.

-- End of Section --

SECTION 09 64 66

WOOD ATHLETIC FLOORING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA M4	(2011) Standard for the Care of Preservative-Treated Wood Products

ASTM INTERNATIONAL (ASTM)

ASTM C109/C109M	(2013) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM D1622	(2008) Apparent Density of Rigid Cellular Plastics
ASTM D2103	(2010) Standard Specification for Polyethylene Film and Sheeting
ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D395	(2003; R 2008) Standard Test Methods for Rubber Property - Compression Set
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

MAPLE FLOORING MANUFACTURERS ASSOCIATION (MFMA)

MFMA AFSFSCL	(2003) Athletic Floor Sealer and Finish Specifications and Conformance List #22
MFMA GRHM	(2000) Grading Rules for MFMA Northern Hardwood Maple

GERMAN INSTITUTE FOR STANDARDIZATION (DIN)

DIN V 18032, Part 2	(2001) Sport halls - Halls for gymnastics, games and multi-purpose use - Part 2: Floors for sporting activities; Requirements testing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Hardwood strip flooring system: G

Clearly delineate components of the system. Show layout of steel channels, location of anchor plate assemblies, floor outlets, and underfloor conduit or raceway location; flooring system details; and flooring abutting other construction. Accessories shall be approved by the flooring manufacturer.

SD-03 Product Data

Hardwood strip flooring components

SD-04 Samples

Strip flooring

Hardwood base

Molded-rubber base

Steel channels and clips

Flexible foam underlayment

Cushions and pads

SD-06 Test Reports

Testing and Certification

SD-08 Manufacturer's Instructions

Flooring system

Adhesive for membrane installation

Submit flooring system manufacturer's installation instructions. Submit vaporproofing manufacturer's written recommendations for adhesives to be used in membrane installation.

SD-10 Operation and Maintenance Data

Hardwood strip flooring, Data Package 1;

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 Testing and Certification

Flooring system shall have been independently tested and evaluated for athletic performance according to the international standard DIN V 18032, Part 2. The performance testing shall be carried out one more time after the floor system has been installed at the jobsite. Floor shall meet or exceed the following DIN Athletic Performance Testing:

a. Ball Rebound - 90% minimum

b. Force Reduction - 53% minimum

c. Vertical Deformation - 2.3 mm minimum

d. Area Indentation - 15% maximum

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the building site in original unopened packages, bundles, or containers. Protect materials against dampness during shipment and after delivery. Store material under cover in a well-ventilated building. Prevent exposure to extreme changes of temperature and humidity. Do not store materials in building under construction until wet-applied building materials are dry. Store flooring in accordance with MFMA GRHM, under adequate and controlled ventilation and under approved temperature and humidity conditions at the location where it is to be laid for at least 7 days before installation. Handle and store preservative-treated materials in accordance with AWPA M4.

1.5 ENVIRONMENTAL CONDITIONS

For at least one week prior to and during installation, in the location to receive finish flooring and the location where flooring will be stored, maintain a temperature of between 18 and 27 degrees C (65 and 80 degrees F), and a relative humidity of between 40 and 60 percent, or as recommended by flooring manufacture. When the interior relative humidity exceeds 60 percent during or after installation of flooring, sanding and finishing of flooring shall be delayed for 2 to 3 weeks after completion of laying, unless directed otherwise. Provide adequate ventilation during the entire sealing and finishing process to ensure that no unhealthy or hazardous accumulation of vapors occurs. Ensure that environmental conditions are met.

PART 2 PRODUCTS

2.1 HARDWOOD STRIP FLOORING SYSTEMS ON CONCRETE SLAB

2.1.1 Clipped to Steel Channels on Underlayment

Provide flooring system consisting of hardwood strip flooring clipped to steel channels that rest in pre-milled grooves in flexible foam underlayment. Anchor steel channels to concrete floor slab.

2.1.2 Plywood Subflooring with Rubber Pads

Provide flooring system consisting of hardwood strip flooring nailed to two-layer plywood subflooring that is seated on cushioned pads resting on the concrete floor slab.

2.2 MATERIALS

2.2.1 Strip Flooring

Second or better grade hard maple graded in accordance with current MFMA GRHM. Flooring shall be 19.8 or 26.2 mm (25/32 or 33/32 inch) thick by 57 or 38 mm (2 1/4 or 1 1/2 inch) or narrower on the face, kiln dried, continuous tongue-and-groove, and end-matched. Each bundle of flooring shall be clearly grade stamped. Moisture content of strip flooring shall not exceed 8 percent at time of arrival on job site and shall be allowed to acclimate in accordance with paragraph entitled "Delivery, Storage, and Handling."

2.2.2 Hardwood Base

Clear hard maple. Provide shape and size of base as indicated or as recommended by the flooring manufacturer.

2.2.3 Molded-Rubber Base

100 mm (4 inch) vertical leg by 75 mm (3 inch), designed to allow ventilation under floor, and as recommended by flooring manufacturer.

2.2.4 Steel Channels and Clips

Provide channels and clips not less than 1.5 mm thick (16 gage) zinc-coated steel.

2.2.5 Rubber Cushions and Pads

Rubber cushions and pads shall have a durometer hardness of A50, plus or minus 5, when tested in accordance with ASTM D2240 and shall have a minimum tensile strength of 10 MPa (1500 psi), when tested in accordance with ASTM D412. When subjected to an aging period of 70 hours and exposed to a temperature of 70 degrees C (158 degrees F), allowed to cool to room temperature over a period of 4 hours and retested, tested specimen shall have a change in hardness of 10 points maximum, a change in tensile strength of minus 25 percent maximum and a change in ultimate elongation of minus 25 percent maximum in accordance with the applicable test methods referenced above. Test rubber cushions, under a load of 275 kPa (40 psi), in accordance with ASTM D395, Method A. Size of tested specimen shall be 57 by 75 by 10 mm (2 1/4 by 3 by 3/8 inch). Length of testing time shall be 22 hours; temperature of test shall be 70 degrees C (158 degrees F). Test specimen shall recover, without set or displacement.

2.2.6 Flexible Foam Underlayment

Multi-cellular, closed-cell flexible polyethylene plastic foam having smooth skin; density 27 to 52 kg/cu m (1.7 to 3.3 pounds per cubic foot) when tested by ASTM D1622. Foam shall be 12.7 mm (1/2 inch) thick by 1200 mm (48 inch) wide by manufacturer's standard length, pre-milled to receive steel channels at 300 mm (12 inch) centers.

2.2.7 Polyethylene Vaporproofing Membrane

ASTM D2103 Type 21110. Minimum thickness shall be 0.15 mm (6 mils). Perm rating shall not exceed 0.02 when tested in accordance with ASTM E96/E96M.

2.2.8 Plywood Subflooring

Douglas fir, southern pine, or western larch plywood; grade C-D, with exterior glue; 12.7 mm (1/2 inch) thick by 1200 by 2400 mm (4 by 8 feet).

2.2.9 Sealing and Finishing for Hardwood Strip Flooring

Conform to MFMA AFSFSCL, Group II, III finish. Seal coat and finish coat materials shall be compatible with each other.

2.2.10 Game Line Marking Materials

As recommended by wood flooring finish manufacturer.

2.2.11 Nails

Shape and size as recommended by flooring manufacturer.

2.2.12 Adhesives

Waterproof, suitable for use with molded rubber base, recommended by rubber base manufacturer.

2.2.13 Self-Leveling Floor Surfacer

Self-finishing interior floor topping/underlayment specially formulated to work without troweling. Self-Leveling Floor Surfacer shall be a blend of portland cement, graded silica aggregates and manufacturer's standard additives. 28-day compressive strength of the product shall be not less than 27.6 MPa4000 psi when tested in accordance with ASTM C109/C109M.

2.2.13.1 Mixing

Mix surfacer powder into water by mechanical means for 4 minutes at 250 to 500 RPM. Always add the surfacer powder to the water. Do not add water to dry powder. The usual amount of mixing water per 22.7 kg50 lb bag is 4.26 L4-1/2 quantity. Mix until the dry material is thoroughly blended and free of lumps.

2.3 TEMPERATURE/HUMIDITY MONITORING DEVICE

Temperature/humidity monitoring device shall be similar with HOBO U14 LCD Logger as manufactured by HOBO Data Loggers or approved equal. Location of mounting will be designated by the Contracting Officer's Representative.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Condition of Subfloors

Do not install flooring on surfaces that are not suitable for proper installation. Before beginning work under this section, correct defects such as rough or scaling concrete, low spots, high spots, uneven surfaces, and repair damaged portions of concrete slabs. Concrete slabs shall be given a leveling course of latex fill and the surface shall not vary more than 3 mm (1/8 inch) when measured with a 3 meter (10 feet) straightedge placed in any direction.

3.1.2 Preparation of Concrete Slab

Sweep concrete floor. Ensure that slab is dry and clean. Remove paint spots, plaster, masonry droppings, grease, dirt, and other foreign matter . Concrete shall be fully cured and dry.

3.1.3 Anchor Plate Assemblies for Portable Sports Equipment

Floor anchor plate assemblies for vertically adjustable portable sports equipment shall be installed where indicated. Flooring shall be cut neatly around floor plates.

3.1.4 Work of Other Trades

Do not start work specified under this section until work of trades which could create moisture, has been completed.

3.1.5 Moisture Content

Check flooring, subflooring, sleepers and nailers with an approved meter verifying conformance with the requirements specified hereinbefore.

3.1.6 Placing of Self-Leveling Floor Surfacer

Place the surfacer by pouring directly from the mixing container. Placing shall be done as one continuous operation. Protect the leveled floor until surfacer has developed sufficient strength to withstand foot traffic.

3.2 INSTALLATION

3.2.1 Vaporproofing For Slabs on Grade

Cover slab with the polyethylene membrane. Lap joints at least 150 mm (6 inch). Seal joints with a full coverage of the adhesive recommended by the membrane manufacturer.

3.2.2 Flooring Clipped to Steel Channels

3.2.2.1 Channel Placing

Install each channel in pre-milled grooves spaced 300 mm (12 inch) on center in flexible foam parallel to the short side of the room, with butted end-to-end joints staggered at least 600 mm (24 inch). Anchor channels to the slab at 350 mm (14 inch) on center with 9 mm (3/8 inch) diameter, flat headed anchors that penetrate the slab by at least 32 mm (1-1/4 inch). Set channels level.

3.2.2.2 Laying of Finished Flooring

Lay finished flooring at right angles to the steel channels. Begin installation with double-tongue strips of flooring in center of room. Clip each board down tightly at each channel intersection with zinc-coated flooring clips. Each clip shall firmly engage the side edges of the flooring and the steel channels. Ensure that each clip is placed properly. Stagger adjacent end joints of flooring so that there will be at least two boards between joints. Where floor plates occur, install steel channels along edges of flooring board; provide clips for flooring. Drive each flooring strip up sideways and endways as tightly as practicable using steel driving tools that prevent marring of exposed flooring. Boards shall be scribed to permanent obstructions and securely blocked at wall lines.

3.2.3 Flooring on Plywood Subflooring With Rubber Pads

3.2.3.1 Installation of Plywood Subflooring With Rubber Pads

Provide two layers of 12.7 mm (1/2 inch) thick plywood sheets, of 1200 by 2400 mm (4 by 8 feet). Each 1200 by 2400 mm (4 by 8 feet) sheet in the bottom layer bearing on slab shall have 32 rubber pads, 57 by 75 by 10 mm (2-1/4 by 3 by 3/8 inch) thick, approximately 300 mm (12 inch) on center in each direction, stapled to underside of sheet. Partial sheets shall have rubber pads 300 mm (12 inch) on center and at perimeters. Lay first layer of plywood on concrete floor slab, parallel to short side of room. Lay second layer at a 45 degree angle to first layer and fasten it to first layer by machine nailing or stapling on 600 mm (24 inch) centers using 25 mm (one inch) nails or staples. Leave a continuous air space 50 mm (2 inch) wide between the subflooring and perimeter walls and other permanent obstructions and 6 mm (1/4 inch) between panels at sides and ends. Lap panels so that no joint will fall over any joint of the first layer. In areas where fixed or temporary seats are indicated, provide fixed hardboard shims, 3 mm (1/8 inch) thick, between the cushioned pads.

3.2.3.2 Laying of Finished Flooring

Begin installation of flooring in center of space with double-tongue strips of flooring. Lay flooring parallel with the long dimension of the room. Flooring shall be blind nailed on 250 mm (10 inch) centers with 45 mm (1-3/4 inch) spiral screw nails. Leave a continuous air space, 50 mm (2 inch) wide, between the finished flooring and perimeter walls and other permanent obstructions. Stagger end joints of adjacent strips of flooring so that there will be at least two boards between each joint.

3.2.4 Hardwood Base Installation

Install molded and perforated continuous hardwood base of the type indicated, along perimeter walls. Base shall have 9 mm (3/8 inch) diameter vent holes spaced 125 mm (5 inch) on center in a straight row. Nail or bolt base to wall. Do not fasten base to flooring.

3.3 SANDING, FINISHING, AND MARKING

3.3.1 Sanding

Sand wood floor surfaces with a machine using coarse, medium, and fine grades of sandpaper; the edges shall be sanded to a smooth edge; the finished surface shall be smooth and level, free from scratches. A final disc sanding shall be provided. After final sanding or buffing, vacuum floors until clean. Do not walk on floors thereafter until finish has been applied and is dry. Contractor shall check drum sander drums for any bumps, tears, out-of-roundness, deformities on surface before each sanding phase, before sandpaper is installed. After sandpaper is installed, the Contractor shall closely observe initial sanding to see if any unusual grooves are present in the wood. The Contractor shall request an inspection by the Contracting Officer before each sanding phase, before and after each sealing phase, and before/after each finishing coat. The

Contractor shall provide sufficient coats of sealer until there are no dry spots evident. Hand sanding small areas to repair finishes shall not be allowed after sealer is applied.

3.3.2 Finishing

Within one day after the final sanding, buffing, and sweeping have been completed, use a tacky rag to clean flooring with a solvent recommended by the manufacturer of the floor finish material. Follow cleaning with a coating of sealer; when thoroughly dry, burnish with No. 2 steel wool, using a power machine. After final burnishing and prior to application of final finish coat(s), layout and mark game lines as specified herein; after game lines are thoroughly dry, apply final finish coat. Floors shall be wiped with a tacky rag each burnishing.

3.3.3 Marking

Lay out game lines and fields where indicated, masking edges to provide sharp, clean edges. Edge shall be straight and width shall be uniform. Apply marking of colors indicated, providing a minimum dry film thickness of 0.023 mm (one mil).

3.4 PROTECTION

After completion of laying, finishing, and marking of the flooring, do not use the floor for at least 72 hours. Avoid heavy traffic on the floor for at least one week. Upon floor drying, use nonstaining, porous building paper of the type and grade recommended by manufacturer, taped along edges. Remove kraft paper covering after work in this area is completed.

3.5 SCHEDULE

Metric measurements in this section are based on mathematical conversion of English unit measurement, and not on metric measurement commonly agreed to by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

Products	English Units	Metric Units
Flooring	25/32 inch	19.8 mm
	33/32 inch	26.2 mm
	2 1/4 inch	57 mm
	1 1/2 inch	38 mm
	1 5/16 inch	33 mm
Rubber Base	4 by 3 inch	100 by 75 mm
Steel Channels	16 gage	1.5 mm
Sleepers	2 by 3 inch	50 by 75 mm

Products	English Units	Metric Units
Plywood	1/2 inch	12.7 mm

-- End of Section --

SECTION 09 65 00

RESILIENT FLOORING
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D4078	(2002; R 2008) Water Emulsion Floor Polish
ASTM E648	(2010; E 2011) Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM F1066	(2004; E 2010; R 2010) Standard Specification for Vinyl Composition Floor Tile
ASTM F1303	(2004; R 2009) Sheet Vinyl Floor Covering with Backing
ASTM F1344	(2012) Rubber Floor Tile
ASTM F1482	(2004; E 2009; R 2009) Installation and Preparation of Panel Type Underlayments to Receive Resilient Flooring
ASTM F1700	(2004; R 2010) Solid Vinyl Floor Tile
ASTM F1859	(2012) Rubber Sheet Floor Covering Without Backing
ASTM F1860	(2012) Rubber Sheet Floor Covering With Backing
ASTM F1861	(2008) Resilient Wall Base
ASTM F1869	(2011) Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
ASTM F2034	(2008) Sheet Linoleum Floor Covering
ASTM F2169	(2012) Resilient Stair Treads
ASTM F2170	(2011) Determining Relative Humidity in Concrete Floor Slabs in situ Probes
ASTM F2195	(2007) Linoleum Floor Tile

ASTM F710	(2011) Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3813	(2004) Resilient Floor Coverings - Cork Floor Tiles

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 253	(2011) Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source

1.2 SYSTEM DESCRIPTION

1.2.1 Fire Resistance Requirements

Provide a critical radiant flux of not less than 0.45 watts per square centimeter (Class 1) for flooring in corridors and exits when tested in accordance with ASTM E648 or NFPA 253.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Scaled Drawings

SD-03 Product Data

Resilient Flooring and Accessories
Adhesives
Sheet Linoleum
Linoleum Tile
Cork

SD-06 Test Reports

Moisture, Alkalinity and Bond Tests

SD-08 Manufacturer's Instructions

Installation

SD-10 Operation and Maintenance Data

Resilient Flooring and Accessories

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the building site in original unopened containers bearing the manufacturer's name, style name, pattern color name and number, production run, project identification, and handling instructions. Store materials in a clean, dry, secure, and well-ventilated area with ambient air temperature maintained above 20 degrees C (68 degrees F) and below 30 degrees C (85 degrees F), stacked according to manufacturer's recommendations. Protect materials from the direct flow of heat from hot-air registers, radiators and other heating fixtures and appliances. Observe ventilation and safety procedures specified in the MSDS.

1.5 ENVIRONMENTAL REQUIREMENTS

Maintain areas to receive resilient flooring at a temperature above 20 degrees C (68 degrees F) and below 30 degrees C (85 degrees F) for 3 days before application, during application and 2 days after application, unless otherwise directed by the flooring manufacturer for the flooring being installed. Maintain a minimum temperature of 13 degrees C (55 degrees F) thereafter. Provide adequate ventilation to remove moisture from area and to comply with regulations limiting concentrations of hazardous vapors.

1.6 SCHEDULING

Schedule resilient flooring application after the completion of other work which would damage the finished surface of the flooring.

1.7 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a one year period.

1.8 EXTRA MATERIALS

Provide extra flooring material of each color and pattern at the rate of 5 tiles for each 1000 tiles and 0.5 square m (5 square feet) for each 92 square m (1000 square feet) of sheet flooring installed. Provide extra wall base material composed of 6 m (20 linear feet) of each type, color and pattern. Package all extra materials in original properly marked containers bearing the manufacturer's name, brand name, pattern color name and number, production run, and handling instructions. Provide extra materials from the same lot as those installed. Leave extra stock at the site in location assigned by Contracting Officer.PART 2 PRODUCTS

2.1 VINYL COMPOSITION TILE

Conform to ASTM F1066 Class 1, (solid color tile), Composition 1, asbestos-free, 300 mm (12 inch) square and 3.2 mm (1/8 inch) thick. Provide color and pattern uniformly distributed throughout the thickness of the tile.

2.2 SHEET VINYL FLOORING

Conform to ASTM F1303, Type I, Grade 1, Class A-non-asbestos formulated fibrous backing or Class B-nonfoamed plastic backing (minimum wear layer thickness 0.5 mm (0.020 inch) and minimum overall thickness 2 mm (0.080 inch)) and a minimum 1800 mm (6 feet) wide. As required, provide welding rods as recommended by the manufacturer for heat welding of joints.

2.3 RUBBER TILE

Conform to ASTM F1344 Class 1 homogeneous, Type A (solid color), 300 mm (12 inch) square. Provide raised round surface studs with chamfered edges. Provide low stud profile. Provide 3.2 mm (0.125 inch) overall thickness.

2.4 RUBBER SHEET FLOORING

Conform to ASTM F1859 (flooring without backing), Type I homogeneous or ASTM F1860 (flooring with backing), Type I homogeneous. Provide smooth surface. Provide 3 mm (0.118 inch) overall thickness.

2.5 SOLID VINYL TILE

Conform to ASTM F1700 Class I monolithic (minimum wear layer thickness 3 mm (0.125 inch) and minimum overall thickness 3 mm (0.125 inch). Provide 300 mm (12 inch) square tile.

2.6 SHEET LINOLEUM TYPE A

Conform to ASTM F2034 and consist of a homogeneous layer of a mixture of linoleum cement (binder in linoleum consisting of a mixture of linseed oil, pine rosin, fossil, or other resins or rosins, or an equivalent oxidized oleoresinous binder), cork and/or wood flour, mineral fillers, and pigments bonded to a jute backing. Provide a minimum 1800 mm (6 feet) wide and overall thickness not less than 2.5 mm (0.100 inch) for linoleum. As required, provide welding rods as recommended by the manufacturer for heat welding of joints.

2.7 LINOLEUM TILE TYPE A

Conform to ASTM F2195 and consist of a homogeneous layer of a mixture of linoleum cement (binder in linoleum consisting of a mixture of linseed oil, pine rosin, fossil, or other resins or rosins, or an equivalent oxidized oleoresinous binder), cork and/or wood flour, mineral fillers, and pigments bonded to a polyester backing. Provide square tiles a minimum 450 mm (18 inch) square and overall thickness 2.0 mm (0.08 inch) minimum for linoleum tile.

2.8 CORK

Conform to ISO 3813, and be 300 mm (12 inches) square and 0.05 m (3/16 inches) to 0.08 m (5/16 inches) thick. Do not use products made with urea-formaldehyde binder.2.9 WALL BASE

Conform to ASTM F1861, Type TS (vulcanized thermoset rubber), Type TP (thermoplastic rubber), or Type TV (thermoplastic vinyl), Style A (straight - installed with carpet), Style B (coved - installed with resilient flooring), or Style C (butt toe cove installed with 3 mm (1/8 inch) thick flooring). Provide 150 mm (6 inch) high and a minimum 3.175 mm (1/8 inch) thick wall base.

2.10 INTEGRAL COVE BASE

Extend integral coved base for sheet vinyl and sheet linoleum flooring up the wall 100 mm (4 inch). Provide a vinyl or rubber , square cap strip and vinyl, rubber, or wood fillet strip with a minimum radius of 19 mm (3/4 inch) for integral coved bases at perimeter and fixed vertical interruptions to flooring . Provide integral cove of the same material as flooring. Provide inside and outside corner protectors of clear anodized aluminum or plastic approved by flooring manufacturer.

2.11 STAIR TREADS, RISERS AND STRINGERS

Conform to ASTM F2169, Type TS (vulcanized thermoset rubber), Type TP (thermoplastic rubber), or Type TV (thermoplastic vinyl). Conform to ASTM F2169 for surface of treads Class 1 smooth and have Group 1 abrasive non-slip strip. Provide round nosing. Provide either a one piece nosing/tread/riser or a two piece nosing/tread design with a matching coved riser.

2.12 MOULDING

Provide tapered mouldings of vinyl or rubber and types as recommended by flooring manufacturer for both edges and transitions of flooring materials specified. Provide vertical lip on moulding of maximum 6 mm (1/4 inch). Provide bevel change in level between 6 and 13 mm (1/4 and 1/2 inch) with a slope no greater than 1:2.

2.13 ADHESIVES

Provide adhesives for flooring, base and accessories as recommended by the manufacturer and comply with local indoor air quality standards. Submit manufacturer's descriptive data, documentation stating physical characteristics, and mildew and germicidal characteristics.

2.14 SURFACE PREPARATION MATERIALS

Provide surface preparation materials, such as panel type underlayment, lining felt, and floor crack fillers as recommended by the flooring manufacturer for the subfloor conditions. Comply with ASTM F1482 for panel type underlayment products.

2.15 POLISH/FINISH

Provide polish finish as recommended by the manufacturer and conform to ASTM D4078 for polish.

2.16 CAULKING AND SEALANTS

Provide caulking and sealants in accordance with Section 07 92 00 JOINT SEALANTS.

2.17 MANUFACTURER'S COLOR, PATTERN AND TEXTURE

Provide color, pattern and texture for resilient flooring and accessories as indicated on the drawings or selected from manufacturer's standard colors. Color listed is not intended to limit the selection of equal colors from other manufacturers. Provide flooring in any one continuous area or replacement of damaged flooring in continuous area from same production run with same shade and pattern. Submit scaled drawings indicating patterns (including location of patterns and colors) and dimensions. Submit manufacturer's descriptive data. Submit Data Package 1 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

2.18 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Examine and verify that site conditions are in agreement with the design package. Report all conditions that will prevent a proper installation. Do not take any corrective action without written permission from the Government. Work will proceed only when conditions have been corrected and accepted by the installer. Submit manufacturer's printed installation instructions for all flooring materials and accessories, including preparation of substrate, seaming techniques, and recommended adhesives.

3.2 SURFACE PREPARATION

Provide a smooth, true, level plane for surface preparation of the flooring, except where indicated as sloped. Floor to be flat to within 4.75 in 3048 mm (3/16 inch in 10 feet). Prepare subfloor in accordance with flooring manufacturer's recommended instructions. Prepare the surfaces of lightweight concrete slabs (as defined by the flooring manufacturer) as recommended by the flooring manufacturer. Comply with ASTM F710 for concrete subfloor preparation. Floor fills or toppings may be required as recommended by the flooring manufacturer. Install underlayments, when required by the flooring manufacturer, in accordance with manufacturer's recommended printed installation instructions. Comply with ASTM F1482 for panel type underlayments. Before any work under this section is begun, correct all defects such as rough or scaling concrete, chalk and dust, cracks, low spots, high spots, and uneven surfaces. Repair all damaged portions of concrete slabs as recommended by the flooring manufacturer. Remove concrete curing and sealer compounds from the slabs, other than the type that does not adversely affect adhesion. Remove paint, varnish, oils, release agents, sealers, waxes, and adhesives, as required by the flooring product in accordance with manufacturer's printed installation instructions.

3.3 MOISTURE, ALKALINITY AND BOND TESTS

Determine the suitability of the concrete subfloor for receiving the resilient flooring with regard to moisture content and pH level by moisture and alkalinity tests. Conduct moisture testing in accordance with ASTM F1869 or ASTM F2170, unless otherwise recommended by the flooring manufacturer. Conduct alkalinity testing as recommended by the flooring manufacturer. Determine the compatibility of the resilient flooring adhesives to the concrete floors by a bond test in accordance with the flooring manufacturer's recommendations. Submit copy of test reports for moisture and alkalinity content of concrete slab, and bond test stating date of test, person conducting the test, and the area tested.

3.4 PLACING VINYL COMPOSITION, LINOLEUM AND SOLID VINYL TILES

Install tile flooring and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's directions. Keep tile lines and joints square, symmetrical, tight, and even. Keep each floor in true, level plane, except where slope is indicated. Vary edge width as necessary to maintain full-size tiles in the field, no edge tile to be less than one-half the field tile size, except where irregular shaped rooms make it impossible. Cut flooring to fit around all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Cut, fit, and scribe edge tile to walls and partitions after field flooring has been applied.

3.5 PLACING SHEET VINYL FLOORING

Install sheet vinyl flooring and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Provide square, symmetrical, tight, and even flooring lines and joints. Keep each floor in true, level plane, except where slope is indicated. Cut flooring to fit around all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Lay out sheets to minimize waste. Cut, fit, and scribe flooring to walls and partitions after field flooring has been applied. Provide chemically bonded or heat welded seams and edges in accordance with the manufacturer's written installation instructions. Finish joints flush, free from voids, recesses, and raised areas.

3.6 PLACING SHEET LINOLEUM FLOORING

Install sheet linoleum flooring and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Provide square, symmetrical, tight, and even flooring lines and joints. Keep each floor in true, level plane, except where slope is indicated. Cut flooring to fit around all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Lay out sheets to minimize waste. Cut, fit, and scribe flooring to walls and partitions after field flooring has been applied. Cut seams by overlapping or underscribing as recommended by the manufacturer. Provide heat welded seams in accordance with there manufacturer's written installation instructions. Finish joints flush, free from voids, recesses, and raised areas. Install flooring with an integral coved base.

3.7 PLACING RUBBER TILE

Install rubber tile and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Provide square, symmetrical, tight, and even flooring lines and joints. Keep each floor in true, level plane, except where slope is indicated. Vary width of edge tiles as necessary to maintain full-size tiles, except where irregular-shaped rooms makes it impossible. Cut flooring to fit around, all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Cut, fit, and scribe flooring to walls and partitions after field flooring has been applied.

3.8 PLACING RUBBER SHEET FLOORING

Install rubber sheet flooring and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Provide square, symmetrical, tight, and even flooring lines and joints. Keep each floor in true, level plane, except where slope is indicated. Cut seams by overlapping or underscribing as recommended by the manufacturer. Lay out sheets to minimize waste. Cut flooring to fit around all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Cut, fit, and scribe flooring to walls and partitions after field flooring has been applied.

3.9 PLACING CORK

Cork tile or plank flooring and accessories shall be installed in accordance with manufacturer's installation instructions.

3.10 PLACING FEATURE STRIPS

Install feature strips in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions.

3.11 PLACING MOULDING

Provide moulding where flooring termination is higher than the adjacent finished flooring and at transitions between different flooring materials. When required, locate moulding under door centerline. Moulding is not required at doorways where thresholds are provided. Secure moulding with adhesive as recommended by the manufacturer. Prepare and apply adhesives in accordance with manufacturer's printed directions. Anchor aluminum moulding to floor surfaces as recommended by the manufacturer.

3.12 PLACING WALL BASE

Install wall base in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Tighten base joints and make even with adjacent resilient flooring. Fill voids along the top edge of base at masonry walls with caulk. Roll entire vertical surface of base with hand roller, and press toe of base with a straight piece of wood to ensure proper alignment. Avoid excess adhesive in corners.

3.13 PLACING STAIR TREADS, RISERS, AND STRINGERS

Secure and install stair treads, risers, and stringers in accordance with manufacturer's printed installation instructions. Cover the surface of treads and risers the full width of the stairs. Provide equal length pieces butted together to cover the treads and risers for stairs wider than manufacturer's standard lengths.

3.14 PLACING INTEGRAL COVED BASE

Install integral cove base in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Shape integral coved base by extending the flooring material 100 mm (4 inch) onto the wall surface. Support cove by a filler. Provide a cap strip at the top of the base. Fill voids along the top edge of base at masonry walls with caulk.

3.15 CLEANING

Immediately upon completion of installation of flooring in a room or an area, dry/clean the flooring and adjacent surfaces to remove all surplus adhesive. Clean flooring as recommended in accordance with manufacturer's printed maintenance instructions and within the recommended time frame. As required by the manufacturer, apply the recommended number of coats and type of polish and/or finish in accordance with manufacturer's written instructions.

3.16 PROTECTION

From the time of installation until acceptance, protect flooring from damage as recommended by the flooring manufacturer. Remove and replace flooring which becomes damaged, loose, broken, or curled and wall base which is not tight to wall or securely adhered.

-- End of Section --

SECTION 09 65 66

RESILIENT ATHLETIC FLOORING
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1054	(2002; R 2007) Rubber Property - Resilience Using a Rebound Pendulum
ASTM D1894	(2011; E 2011) Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2632	(2001; R 2008) Rubber Property-Resilience by Vertical Rebound
ASTM D395	(2003; R 2008) Standard Test Methods for Rubber Property - Compression Set
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D624	(2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM F1303	(2004; R 2009) Sheet Vinyl Floor Covering with Backing
ASTM G21	(2013) Determining Resistance of Synthetic Polymeric Materials to Fungi

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G

SD-03 Product Data

Installation

1.3 QUALITY ASSURANCE

1.3.1 Adhesive Application

Adhesive applied and poured-in-place flooring shall be installed by an experienced floor applicator approved by the manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver Materials in manufacturer's original unopened containers with labels intact. Materials shall not be delivered to the installation area or installed before all work that may damage the materials or the finished floor, such as overhead work, is completed. Store materials in a clean, dry area. Materials in storage shall be maintained at temperatures recommended by the manufacturer. Protection boards shall be stored flat and off the ground.

1.5 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a one year period.

1.6 EXTRA MATERIALS

1.6.1 Floor Tiles

Furnish spare tiles of each color at the rate of 5 tiles for each 1000 tiles installed. Tiles shall be from the same lot as those installed.

1.6.2 Carpeting

Extra material from same dye lot consisting of full width continuous broadloom shall be provided for maintenance. A minimum of 5 percent of total square meters (square yards) of each carpet type, pattern, and color shall be provided.

PART 2 PRODUCTS

2.1 INDOOR-OUTDOOR CARPETING TYPE

Carpet-type flooring shall be spike proof ribbed or berber pattern consisting of a top layer of rugged polypropylene or nylon fibers combined with an inorganic cut-resistant backing. Minimum total thickness shall be 10 mm (0.375 inches). Finished surface pile yarn weight (face weight) shall be as indicated. Test results for resistance to soil bacteria or fungi shall show no sustained growth or discoloration after 21 days when tested in accordance with ASTM G21.

2.2 RUBBER COMPOSITION TILE TYPE

Rubber tiles shall be interlocked 600 x 600 mm (24 x 24 inches) square, of solid first quality rubber, uniformly resilient material designed to be applied with or without adhesive. Tiles shall be approximately 13 mm (1/2 inch) thick, shall be smooth texture, and shall be reversible. Flooring shall be able to withstand 75 percent compression for 22 hours at 70 degrees C (158 degrees F) without residual deformation when tested in accordance with ASTM D395. Flooring shall have a durometer hardness Shore-A of 50-60 when tested in accordance with ASTM D2240.

2.3 RUBBER POURED-IN-PLACE FLOORING TYPE

The resilient poured-in-place rubber surface shall be composed of chloroprene rubber, chloroprene rubber sponge, aggregate, setting powders, and a top finish composed of acrylic resins. Flooring shall be able to withstand 50 percent compression for 72 hours at 22 degrees C (72 degrees F) with a residual deformation of less than 10 percent when tested in accordance with ASTM D395. Flooring shall have a minimum compression modulus at 10 percent of 690 kPa (100 psi), a minimum elongation of 250 percent and a minimum tensile strength of 3800 kPa (550 psi) plus or minus 34 kPa (5 psi) when tested in accordance with ASTM D412. Flooring shall have a durometer hardness Shore-A of 55-60 when tested in accordance with ASTM D2240 and a minimum tear resistance of 10.5 kN/m (60 lbf/inch) when tested in accordance with ASTM D624.

2.4 SHEET RUBBER COMPOSITION FLOORING TYPE

Sheet rubber flooring shall be prefabricated, homogeneous, natural and synthetic rubbers, and shall be minimum 5 mm (3/16 inch) thick, and shall have smooth gymnasium finish. Flooring shall be roll type not less than 1500 mm (60 inches) wide. Flooring shall have a minimum tensile stress at 100 percent elongation of 1500 kPa (220 psi) and a minimum ultimate elongation of 250 percent when tested in accordance with ASTM D412. Flooring shall be able to withstand 50 percent compression for 72 hours at 22 degrees C (72 degrees F) with a residual deformation of less than 10 percent when tested in accordance with ASTM D395. Flooring shall provide a 55 plus or minus 5 percent rebound when tested in accordance with ASTM D1054.

2.5 SHEET VINYL COMPOSITION FLOORING TYPE

Sheet vinyl flooring shall consist of a solid polyvinyl chloride material which shall conform to the chemical resistance requirements of ASTM F1303. Flooring shall be not less than 1200 mm (48 inches) wide and shall have a minimum thickness of 3 mm (1/8 inch). Floor surface shall be smooth texture. Flooring shall have a minimum coefficient of friction of 0.75 when tested in accordance with ASTM D1894. Flooring shall have an average thickness loss of 0.2 mm (8.0 mils) plus or minus 0.025 mm (1 mil). Rebound resilience of flooring shall be greater than 12 percent and less than 30 percent when tested in accordance with ASTM D2632.

2.6 URETHANE POURED-IN-PLACE FLOORING TYPE

The resilient poured-in-place urethane surface shall be composed of a seamless pigmented monolithic material. Flooring shall be minimum 3 mm (1/8 inch) thick and shall have smooth gymnasium finish, unless otherwise indicated. Flooring shall have a durometer hardness Shore-A of 55-60 when tested in accordance with ASTM D2240. Flooring shall have a minimum ultimate elongation of 250 percent when tested in accordance with ASTM D412 and shall have a density of 1.25.

2.7 RESILIENT MAT UNDERLAY

Resilient mat underlay shall be prefabricated granulated indoor/outdoor rubber mat bound with polyurethane for shock absorption. Mat thickness shall be as indicated.

2.8 ADHESIVES

Adhesive shall be as recommended by the flooring manufacturer and correspond to the specified flooring product and to the substrate.

2.9 CRACK FILLER/LEVELER FOR CONCRETE SURFACES

Crack filler/leveler for concrete floor surfaces shall be as recommended by flooring manufacturer.

2.10 EDGING STRIPS

Strips shall be of the same material and design as recommended by flooring manufacturer.

2.11 PRIMER

Concrete primer shall be as recommended by flooring manufacturer and correspond to the specified flooring product and to the substrate.

2.12 GAME LINE MATERIAL

Game line material shall as recommended by the flooring manufacturer and correspond to the specified flooring product.

2.13 WALL BASE

Base shall be rubber or vinyl, Type coved style. Base shall be 100 mm (4 inches) high and minimum 2 mm (0.080 inch) thick.

2.14 SEALANTS

Sealants shall be in accordance with Section 07 92 00 JOINT SEALANTS.

2.15 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated in above paragraph under the contractor's quality control approval. These materials should be certified and listed in Korean Industrial Standards (KS) as a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Concrete surfaces shall be completely cured and dry. No curing agents, sealers, or hardeners shall be used to aid in the curing of the concrete slab. Surfaces shall be free of paint spots, and other foreign materials. Surfaces shall be ground down or leveled with an approved leveling compound to a tolerance of plus or minus 3 mm (1/8 inch) within a 3 meters (10 foot) radius. Cracks, construction joints, or damaged portions of floor shall be filled with crack filler for concrete surfaces. Expansion joints shall be filled and sealed in accordance with the approved installation instructions of the manufacturer. All sealants shall be in accordance with ASTM C920. Expansion joints shall not be filled with a material that will make them inoperable.

3.2 MOISTURE TEST

The suitability of the concrete subfloor for receiving the resilient flooring with regard to moisture content shall be determined by a moisture test as recommended by the flooring manufacturer.

3.3 INSTALLATION

3.3.1 General Requirements

Installation shall be in accordance with the approved installation instructions. Tile or sheet flooring shall be rolled with a medium-sized roller in both directions to release entrapped air. Submit manufacturer's descriptive data and catalog cuts indicating materials of construction and physical characteristics. Installation, cleaning and maintenance instructions shall be included.

3.3.2 Molded Rubber Base

Base shall be installed in accordance with the approved installation instructions of the manufacturer of the base.

3.3.3 Indoor-Outdoor Carpeting

Application of flooring shall be as recommended by the manufacturer.

3.3.4 Sheet Vinyl Composition Flooring

Concrete slab shall be primed in accordance with approved installation instructions. Flooring shall be installed as recommended by the manufacturer.

3.3.4.1 Seams

End seams shall be cut and placed as recommended by the manufacturer. Seams shall be weighted as required.

3.3.4.2 Hot-welded Seams

Butted sheets shall be grooved to a depth of approximately two thirds of their total thickness using an electrical or hand grooving tool. Grooved seams shall be thermowelded using a hot air welding tool and a PVC welding thread. After seam has cooled to room temperature, the excess shall be trimmed off to provide a flush joint.

3.3.5 Sheet Rubber Composition Flooring

Sheet flooring shall be dry cut and laid out flat a minimum of 24 hours prior to adhering to the substrate. End seams shall be single cut. Edge seams shall be cut through overlapping sheets, then snapped into place to ensure tight seams. Seams shall be weighted as required.

3.3.6 Rubber Composition Tile Flooring

3.3.6.1 Application With Adhesive

Tiles shall be laid on adhesive surface in pattern according to approved detail drawings. Joints of tiles shall be even and tight. Tiles shall be cut to fit tightly against the wall. Submit drawings showing game lines, location of anchor plate assemblies, floor outlets, and under-floor conduit or raceways.

3.3.6.2 Application Without Adhesive

Tiles shall be joined together using interlocking ears or other mechanical locking techniques. The ears shall interlock into the adjoining tile 40 mm (1-1/2 inches) and shall provide at least five interlocks for each 600 mm (24 inch) edge. Where required, a beveled transfer border shall be supplied to interlock with the flooring tiles. The borders shall be 150 mm (6 inches) wide and 600 mm (24 inches) long and the same thickness as the matching tiles.

3.3.7 Rubber Poured-in-Place Flooring

Concrete slab shall be primed with primer recommended by manufacturer in a thin film covering approximately 10 square meters/L (400 square feet per gallon). Chloroprene rubber shall be poured onto subfloor and troweled to a smooth and uniform layer of the required thickness. A grout chloroprene rubber coat shall be applied to fill possible voids in surface. After the chloroprene rubber is completely dry, a pigmented finish shall be applied with a spray and roller.

3.3.8 Urethane Poured-in-Place Flooring

Concrete slab shall be primed with primer recommended by the manufacturer. Rate of application shall be in accordance with approved installation instructions and shall be allowed to dry odor free. Concrete construction joints shall be covered with 50 mm (2 inch) wide PVC duct tape. Resin shall be applied in a minimum of 2 lifts. Pigmented and textured coatings shall be applied in accordance with manufacturer's recommendations.

3.3.9 Resilient Mat Underlay

The resilient mat underlay shall be unrolled and allowed to relax prior to cutting or fitting. Mat shall be installed in accordance with manufacturers instructions.

3.3.10 Line Marking and Finishing

After installation is complete, the floor surface shall be cleaned in accordance with installation instructions. Line marking shall be laid out, masked, and painted according to approved detail drawings and approved installation instructions. Finishing shall be in accordance with the manufacturer's recommendations.

3.4 PROTECTION

The installed flooring shall be protected from soiling and damage with heavy reinforced, nonstaining kraft paper, plywood, or hardboard sheets as required. Edges of kraft paper protection shall be lapped and secured to provide a continuous cover. Protective covering shall be removed when directed by the Contracting Officer.

-- End of Section --

SECTION 09 68 00

CARPET
05/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC 107	(2009; E 2010) Colorfastness to Water
AATCC 134	(2011) Electrostatic Propensity of Carpets
AATCC 16	(2004; E 2008; E 2010) Colorfastness to Light
AATCC 165	(2008; E 2011) Colorfastness to Crocking: Textile Floor Coverings - Crockmeter Method
AATCC 174	(2011) Antimicrobial Activity Assessment of Carpets

ASTM INTERNATIONAL (ASTM)

ASTM D1667	(2005; R 2011) Flexible Cellular Materials - Poly (Vinyl Chloride) Foam (Closed-Cell)
ASTM D297	(1993; R 2006) Rubber Products - Chemical Analysis
ASTM D3278	(1996; R 2011) Flash Point of Liquids by Small Scale Closed-Cup Apparatus
ASTM D3676	(2007) Rubber Cellular Cushion Used for Carpet or Rug Underlay
ASTM D5793	(2005) Binding Sites Per Unit Length or Width of Pile Yarn Floor Coverings
ASTM D5848	(2010; E 2010) Mass Per Unit Area of Pile Yarn Floor Coverings
ASTM D6859	(2011) Standard Test Method for Pile Thickness of Finished Level Pile Yarn Floor Coverings
ASTM E648	(2010; E 2011) Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source

CARPET AND RUG INSTITUTE (CRI)

CRI 104	(2002) Standard for Installation Specification of Commercial Carpet

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2551	(1981) Machine-made Textile Floor Coverings - Determination of Dimensional Changes Due to the Effects of Varied Water and Heat Conditions

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1630	Standard for the Surface Flammability of Carpets and Rugs (FF 1-70)

WOOLMARK COMPANY (WBI)

Woolmark	(1964) Certification for Use of 100 Percent Wool

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G

SD-03 Product Data

Carpet; G
Carpet Cushion; G
Carpet Moldings; G

SD-06 Test Reports

Moisture and Alkalinity Tests

SD-07 Certificates

Carpet Cushion and Molding

SD-08 Manufacturer's Instructions

Printed Installation Instructions

SD-10 Operation and Maintenance Data

Cleaning and Protection

1.3 QUALITY ASSURANCE

Provide the Carpet and Rug Institute (CRI) Indoor Air Quality (IAQ) label for carpet, carpet cushion, and adhesives or demonstrate compliance with testing criteria and frequencies through independent laboratory test results. Carpet, carpet cushion, and adhesives bearing the label will indicate that the carpet has been tested and meets the Regulatory Requirements and criteria of the CRI IAQ Carpet Testing Program, and minimizes the impact on indoor air quality. Submit certificates, showing conformance with the referenced standards contained in this section, for the following: Carpet Cushion and Molding.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site in the manufacturer's original wrappings and packages clearly labeled with the manufacturer's name, brand name, size, dye lot number, and related information. Remove materials from packaging and store them in a clean, dry, well ventilated area protected from damage, soiling, and moisture, and maintain at a temperature above 16 degrees C (60 degrees F) for 2 days prior to installation. Do not store carpet near materials that may off gas or emit harmful fumes, such as kerosene heaters, fresh paint, or adhesives.

1.5 AMBIENT CONDITIONS

Maintain areas in which carpeting is to be installed at a temperature above 16 degrees C (60 degrees F) and below 32 degrees C (90 degrees F) for 2 days before installation, during installation, and for 2 days after installation. Provide temporary ventilation during work of this section. Maintain a minimum temperature of 13 degrees C (55 degrees F) thereafter for the duration of the contract. Do not permit traffic or movement of furniture or equipment in carpeted area for 24 hours after installation. Complete other work which would damage the carpet prior to installation of carpet.

1.6 WARRANTY

Provide manufacturer's standard performance guarantees or warranties including minimum ten (10) year wear warranty, two (2) year material and workmanship and ten (10) year tuft bind and delamination.

PART 2 PRODUCTS

2.1 CARPET

Furnish first quality carpet; free of visual blemishes, streaks, poorly dyed areas, fuzzing of pile yarn, spots or stains, and other physical and manufacturing defects. Provide carpet materials and treatments as reasonably nonallergenic and free of other recognized health hazards. Provide a static control construction on all grade carpets which gives adequate durability and performance. Submit Manufacturer's catalog data and printed documentation stating physical characteristics, durability, resistance to fading, and flame resistance characteristics for each type of carpet material and installation accessory. Submit manufacturer's catalog data for the following items: 1) Carpet Cushion and 2) Carpet Moldings.

2.1.1 Broadloom, Modular Tile, and Entrance

Carpet shall comply with the following:

a. Carpet Construction: Tufted, Woven, Bonded, or Needlebond, as indicated.

b. Type: Broadloom 1.8 m (6 feet) minimum usable carpet width with exception of corridors and stairs. Modular tile 450 by 450, 500 by 500, or 600 by 600 mm square (18 by 18, 20 by 20, or 24 by 24 inch square) with 0.15 percent growth/shrink rate in accordance with ISO 2551. Entrance 450 by 450 mm (18 by 18 inch) square mat size, unless otherwise indicated.

c. Pile Type: Level-loop, Multilevel loop, Cut and loop, Frieze, Cut pile, Random sheared, or Level tip shear, as indicated.

d. Pile Fiber: Commercial 100 percent branded (federally registered trademark) nylon continuous filament, nylon staple, wool with Woolmark certification, wool blend with Wool Bureau certification, cotton, jute, sisal, hemp, or polylactic acid (PLA), minimum 85 percent biobased materials. Chemical treatments, including moth treatment, are permitted with written approval from the Contracting Officer.

e. Yarn Ply: Minimum 2.

f. Gauge or Pitch: In accordance with ASTM D5793.

g. Stitches or Rows/Wires: Minimum 9 per square meter.

h. Surface Pile Weight: Minimum 0.73 kg/square meter (26 ounces per square yard). This does not include weight of backings. Determine weight in accordance with ASTM D5848.

i. Pile Thickness: As indicated, in accordance with ASTM D6859.

j. Pile Density: Minimum, 36 x Pile Weight / Pile Thickness.

k. Dye Method: Solution dyed, Stock dyed, Yarn (or Skein) dyed, Piece dyed, Space dye, or Continuous dye.

l. Backing Materials: Provide primary backing materials like those customarily used and accepted by the trade for each type of carpet. Provide secondary backing to suit project requirements of those customarily used and accepted by the trade for each type of carpet, except when a special unitary back designed for gluedown is needed.

m. Attached Cushion: Provide an attached cushion chemically frothed polyurethane with minimum weight of 0.610 kg/sq. m (18 oz/sq. yard), minimum density of 176 kg/cubic m (11 lb/cubic foot) or mechanically frothed polyurethane with minimum weight of 0.745 kg/sq. m (22 oz/sq. yard), minimum density of 224 kg/cubic m (14 lb/cubic foot), minimum thickness of 2.5 mm (0.100 inch), and maximum compression resistance of 34.5 kPa (5 psi), and compression set of 15 percent in accordance with ASTM D3676. Do not exceed the maximum ash content of 50 percent when tested in accordance with ASTM D297. Pass the accelerated aging test in accordance with ASTM D3676 or ASTM D1667 for the cushion.

2.2 PERFORMANCE REQUIREMENTS

a. Static Control: Provide static control to permanently regulate static buildup to less than 3.5 kV when tested at 20 percent relative humidity and 21 degrees C (70 degrees F) in accordance with AATCC 134, unless otherwise indicated.

b. Flammability and Critical Radiant Flux Requirements: Comply carpet with 16 CFR 1630. Provide carpet in corridors and exits with a minimum average critical radiant flux of 0.45 watts per square centimeter when tested in accordance with ASTM E648.

c. Tuft Bind: Provide tuft bind force required to pull a tuft or loop free from carpet backing with a minimum 40 N (10 pound) average force for loop pile.

d. Colorfastness to Crocking: Comply dry and wet crocking with AATCC 165 and with a Class 4 minimum rating on the AATCC Color Transference Chart for all colors.

e. Colorfastness to Light: Comply colorfastness to light with AATCC 16, Test Option E "Water-Cooled Xenon-Arc Lamp, Continuous Light" and with a minimum 4 gray scale rating after 40 hours.

f. Colorfastness to Water: Comply colorfastness to water with AATCC 107 and with a minimum 4.0 gray scale rating and a minimum 4.0 transfer scale rating.

g. Delamination Strength: Provide delamination strength for tufted carpet with a secondary back of minimum 440 N/m (2.5 lbs/inch).

h. Antimicrobial: Nontoxic antimicrobial treatment in accordance with AATCC 174 Part I (qualitative), guaranteed by the carpet manufacturer to last the life of the carpet.

2.3 CARPET CUSHION

Fiber Cushion: Rubberized hair or jute, mothproofed and sterilized,, Synthetic Resinated, or recycled textile.Polyurethane-Foam Cushion: Grafted prime, Densified, Bonded, or Mechanically frothed.Performance Characteristics - Critical Radiant Flux Classification: Not less than 0.45 W/sq.cm.

2.4 ADHESIVES AND CONCRETE PRIMER

Adhesives and concrete primers shall comply with applicable regulations regarding toxic and hazardous materials. Provide water resistant, mildew resistant, nonflammable, and nonstaining adhesives and concrete primers for carpet installation as required by the carpet manufacturer. Provide release adhesive for modular tile carpet as recommended by the carpet manufacturer. Provide adhesives flashpoint of minimum 60 degrees C (140 degrees F) in accordance with ASTM D3278.

2.5 MOLDINGS

Install carpet moldings, either vinyl or aluminum, where floor covering material changes or carpet edge does not abut a vertical surface. Provide a hammered surface aluminum molding, pinless clamp-down type, designed for the type of carpet being installed. Provide natural color anodized finish. Provide a floor flange of a minimum 38 mm (1-1/2 inch) wide and face a minimum 16 mm (5/8 inch) wide.

2.6 TAPE

Provide tape for seams as recommended by the carpet manufacturer for the type of seam used in installation.

2.7 COLOR, TEXTURE, AND PATTERN

Provide color, texture, and pattern in accordance with as indicated.

2.8 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Do not install carpet on surfaces that are unsuitable and will prevent a proper installation. Prepare subfloor in accordance with flooring manufacturer's recommended instructions. Repair holes, cracks, depressions, or rough areas using material recommended by the carpet or adhesive manufacturer. Free floor of any foreign materials and sweep clean. Before beginning work, test subfloor with glue and carpet to determine "open time" and bond. Submit one hard copy & one digital copy (.pdf - text searchable) of the manufacturer's printed installation instructions for the carpet, including preparation of substrate, seaming techniques, and recommended adhesives and tapes.

3.2 MOISTURE AND ALKALINITY TESTS

Test concrete slab for moisture content and excessive alkalinity in accordance with CRI 104. Submit one hard copy & one digital copy (.pdf - text searchable) of test reports of moisture and alkalinity content of concrete slab stating date of test, person conducting the test, and the area tested.

3.3 PREPARATION OF CONCRETE SUBFLOOR

Do not commence installation of the carpeting until concrete substrate is at least 90 days old. Prepare the concrete surfaces in accordance with instructions of the carpet manufacturer. Match carpet, when required, and adhesives to prevent off-gassing to a type of curing compounds, leveling agents, and concrete sealer.

3.4 INSTALLATION

Perform all work by manufacturer's approved installers. Conduct installation in accordance with the manufacturer's printed instructions and CRI 104. Protect edges of carpet meeting hard surface flooring with molding and install in accordance with the molding manufacturer's printed instructions. Follow ventilation, personal protection, and other safety precautions recommended by the adhesive manufacturer. Continue ventilation during installation and for at least 72 hours following installation. Submit one hard copy & one digital copy (.pdf - text searchable) of drawings indicating areas receiving carpet, carpet types, textures and patterns, direction of pile, location of seams, and locations of edge molding. Submit installation drawings for: 1) Carpet Cushion and 2) Carpet Moldings diagramming the location of seams, edge moldings, and carpet direction for approval prior to installation.

3.4.1 Broadloom Installation

Install broadloom carpet direct glue down or pre-applied adhesive glue down and smooth, uniform, and secure, with a minimum of seams. Apply regular, unnoticeable, and treated seams with a seam adhesive. Run side seams toward the light, where practical, and where such layout does not increase the number of seams. Install breadths parallel, with carpet pile in the same direction. Match patterns accurately. Neatly cut and fit cutouts, at door jambs, columns and ducts securely. Locate seams at doorways parallel to and centered directly under doors. Do not make seams perpendicular to doors or at pivot points. Provide seams at changes in directions of corridors to follow the wall line parallel to the carpet direction. Lay the carpet lengthwise down the corridors with widths less than 1.8 m (6 feet).

3.4.2 Modular Tile Installation

Install modular tiles with permanent vinyl-compatible adhesive and snugly jointed together. Lay tiles in the same direction with accessibility to the subfloor where required.

3.4.3 Entrance Carpet Installation

Install tiles with permanent vinyl-compatible adhesive and shall be snugly jointed together. Lay tiles in the same direction. Install roll goods direct glue down and smooth, uniform, and secure, with a minimum of seams. Prepare regular, unnoticeable, and treated seams with a seam adhesive. Install breadths parallel, with carpet pile in the same direction. Match patterns accurately. Neatly cut and fit, securely, cutouts at door jambs, columns, and ducts. Locate seams at doorways parallel to and centered directly under doors. Do not make seams perpendicular to doors or at pivot points.

3.5 CLEANING AND PROTECTION

Submit one hard copy & one digital copy (.pdf - text searchable) carpet manufacturer's maintenance instructions describing recommended type of cleaning equipment and material, spotting and cleaning methods, and cleaning cycles.

3.5.1 Cleaning

As specified in Section 01 78 00 CLOSEOUT SUBMITTALS. After installation of the carpet, remove debris, scraps, and other foreign matter. Remove soiled spots and adhesive from the face of the carpet with appropriate spot remover. Cut off and remove protruding face yarn. Vacuum carpet clean.

3.5.2 Protection

Protect the installed carpet from soiling and damage with heavy, reinforced, nonstaining kraft paper, plywood, or hardboard sheets. Lap and secure edges of kraft paper protection to provide a continuous cover. Restrict traffic for at least 48 hours. Remove protective covering when directed by the Contracting Officer.

3.6 REMNANTS

Manage waste as specified in the Waste Management Plan. Provide remnants remaining from the installation, consisting of scrap pieces more than 600 mm (2 feet) in dimension with more than 0.6 square meters (6 square feet) total to the Government. Remove non-retained scraps from site and recycle appropriately.

3.7 MAINTENANCE

3.7.1 Extra Materials

Provide extra material from same dye lot consisting of full width continuous broadloom and uncut carpet tiles for future maintenance. Provide a minimum of 2 percent of total square meters (square yards) of each carpet type, pattern, and color.

-- End of Section --

SECTION 09 69 13

RIGID GRID ACCESS FLOORING
11/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC 134	(2011) Electrostatic Propensity of Carpets
AATCC 16	(2004; E 2008; E 2010) Colorfastness to Light

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E30	(2011) Engineered Wood Construction Guide
APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B85/B85M	(2010) Standard Specification for Aluminum-Alloy Die Castings
ASTM E648	(2010; E 2011) Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1066	(2004; E 2010; R 2010) Standard Specification for Vinyl Composition Floor Tile

CEILINGS AND INTERIOR SYSTEMS CONSTRUCTION ASSOCIATION (CISCA)

CISCA Access Floors	(2007) Recommended Test Procedures for Access Floors

COMPOSITE PANEL ASSOCIATION (CPA)

CPA A208.1	(2009) Medium Density Fiberboard (MDF) For Interior Applications

CPA A208.2	(2009) Medium Density Fiberboard (MDF) for Interior Applications

ICC EVALUATION SERVICE, INC. (ICC-ES)

ICC-ES AC300	(2009) Acceptance Criteria for Access Floors

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2012) International Building Code

KOREAN INDUSTRIAL STANDARDS (KS)

KS M 3802	(2008) Floor Covering - PVC

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA LD 3	(2005) Standard for High-Pressure Decorative Laminates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 75	(2013) Standard for the Protection of Information Technology Equipment
NFPA 99	(2015) Health Care Facilities Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-C-490	(Rev E) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings

UNDERWRITERS LABORATORIES (UL)

UL 779	(2011) Standard for Electrically Conductive Floorings

1.2 SYSTEM DESCRIPTION

Install access flooring at the location and elevation and in the arrangement shown on the drawings. The floor system shall be of the rigid grid stringer type, complete with all supplemental items, and be the standard product of a manufacturer specializing in the manufacture of access flooring systems.

a. Provide for self-alignment of floor panels, adjustable pedestals and readily removable floor panels covered as specified.

b. Lateral stability of floor support system shall be independent of panels. Provide a finished assembly that is rigid and free of vibration, noises, and rocking panels. If indicated on contract drawings, provide bolted stringer system with equipotential plane grounding.

c. Submit Certificates for the complete Access Flooring System including, but not limited to the following:

   (1) Compliance with ICC-ES AC300. Submit design data substantiating compliance with International Building Code Acceptance Criteria for Access Floors.

   (2) Load-bearing capabilities of pedestals, floor panels, and pedestal adhesive resisting force.

   (3) Supporting independent laboratory test reports. For panel loads, test results include concentrated loads at center of panel, panel edge midpoint, ultimate loads and uniform loads.

   (4) Floor electrical characteristics.

   (5) Material requirements

   (6) An elevated floor system free of defects in materials, fabrication, finish, and installation, that will remain so for a period of not less than 10 years after completion.

d. Warrant that, upon notification by the Government, defective work will be immediately replaced with new work at no additional cost to the Government.

e. Submit manufacturer's descriptive data, catalog cuts, and installation instructions. Include in the data information about any design and production techniques, total system including all accessories and finish coatings of under-floor components, procedures and policies used to conserve energy, reduce material, improve waste management or incorporate green building/recycled products into the manufacturer of their components or products. Include cleaning and maintenance instructions. Systems which contain zinc electroplated anti-corrosion coatings are prohibited.

1.2.1 Allowable Tolerances

a. Floor Panel Flatness: Plus or minus 0.5 mm (0.02 inches) on diagonal on top of panel or underneath edge.

b. Floor Panel Length: Plus or minus 0.4 mm (0.015 inch).

c. Floor Panel Squareness: Plus or minus 0.5 mm (0.02 inch) in panel length.

d. Finish Floor: Level within plus or minus 1.6 mm in 2 meters (0.062 inch in 10 feet), and plus or minus 2.5 mm (0.10 inch) for entire floor.

1.2.2 Floor Panels

Conduct floor panel testing in accordance with CISCA Access Floors. When tested as specified, make all deflection and deformation measurements at the point of load application on the top surface of the panel. Floor panels shall be capable of supporting the following loads, unless otherwise indicated on contract drawings:

a. Concentrated load of 5560 N (1250 pounds) on 645 square mm (one square inch), at any point on panel, without a top-surface deflection more than 2.54 mm (0.10 inch), and a permanent set not to exceed 0.25 mm (0.01 inch) in any of the specified tests.

b. Uniform live load of 14.36 kPa/square meter (300 psf), without a top-surface deflection more than 1.5 mm (0.06 inch), and a permanent set not to exceed 0.25 mm (0.01 inch) in any of the specified tests.

c. A rolling load of 4450 N (1000 pounds) applied through hard rubber surfaced wheel 152 mm (6 inch) diameter by 51 mm (2 inch) wide for 10,000 cycles over the same path. Permanent set at conclusion of test shall not exceed 1.0 mm (0.040 inch).

d. A rolling load of 5560 N (1250 pounds) applied through a 75 mm (3 inch) diameter by 30 mm (1-13/16 inch) wide caster for 10 cycles over the same path, without developing a local overall surface deformation greater than 1 mm (0.04 inch). In accordance with CISCA Access Floors, the permanent deformation limit under rolling load shall be satisfied in all of the specified tests.

e. An impact load of 670 N (150 pounds) anywhere on the panel dropped from a height of 914 mm (36 inches) onto a 645 square mm (1 square inch) area without failure of the system, according to CISCA Access Floors, Section 8 Drop Impact Load Test.

f. Ultimate Concentrated Load. Panels shall provide a safety factor of 3 times the specified concentrated load indicated above, when tested in accordance with CISCA Access Floors, Section 2 Ultimate Loading.

1.2.3 Stringers

Provide stringers capable of supporting a 1110 N (250 pound) concentrated load at midspan without permanent deformation in excess of 0.25 mm (0.010 inch).

1.2.4 Pedestals

Pedestals shall be capable of supporting a 22.24 kN (5000 pound) axial load without permanent deformation.

1.2.5 Bonding Strength of Pedestal Adhesive

Adhesive for anchoring pedestal bases shall have a bonding strength capable of resisting an overturning moment of 113 Nm (1,000 lbf-in) when a force is applied to the top of the pedestal in any direction.

1.2.6 Bond Strength of Factory Installed Covering

Bond strength of floor covering shall be sufficient to permit handling of the panels by use of the panel lifting device, and to withstand moving caster loads up to 4.45 kN (1000 pounds), without separation of the covering from the panel.

1.2.7 Seismic Calculations

1.2.7.1 Army Requirements

Submit calculations for special bracing to resist the effects of seismic or other forces in accordance with UFC 3-310-04, ICC IBC and ICC-ES AC300 . Submit design calculations which demonstrate that the proposed floor system meets requirements for seismic loading. Certified copies of test reports may be submitted in lieu of calculations.

1.2.8 Air Leakage

When the space below the finished floor is an air plenum, air leakage through the joints between panels and around the perimeter of the floor system shall not exceed 0.15 L/s of air per linear meter (0.1 cubic foot of air per minute per linear foot) of joint subjected to 2.5 mm (0.1 inch), water gauge, positive pressure in the plenum. Measure the leakage rate on the finished raised floor system, which may include carpet.

1.2.9 Grounding

Ground the access flooring system for safety hazard and static suppression. Provide positive contact between components for safe, continuous electrical grounding of entire floor system. Total system resistance from wearing surface of floor to building grounding electrode shall be within range of 0.025 to 1.0 megohms, unless otherwise indicated.

1.2.9.1 Metal Grilles

Exposed metal is not allowed at wearing surface of access floor system, except at metal grilles and registers. When grilles and metal registers are provided, insulate as required to provide same grounding resistance as wearing surface.

1.2.9.2 Joint Resistance

Electrical joint resistance between individual stringer and pedestal junctions shall be less than 0.1 milliohms. Electrical resistance between stringers and floor panels, as mounted in normal use, shall be less than 3 ohms.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Installation Drawings; G

SD-03 Product Data

Floor Panels

SD-05 Design Data

Compliance with ICC-ES AC300
Seismic Calculations

SD-06 Test Reports

Electrical Resistance
Acceptance Tests

SD-07 Certificates

Access Flooring System

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

Submit drawings showing location, details at floor perimeter, method of anchorage to structural subfloor, grounding, description of shop or factory coating, installation height above structural floor, stairs, ramps, accessories and other details as specified. Take measurements from finished areas at site and submit Detailed Installation Drawings indicating:

a. Location of panels

b. Layout of supports, panels, and cutout locations

c. Stair, handrail, and ramp framing

d. Sizes and details of components

e. Lateral bracing

f. Typical cutout details

g. Gasketing, return air grilles, supply air registers, and perforated panels. Include air transfer capacity of grilles, registers and panels

h. Floor finishes

i. Location of connection to building grounding electrode

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver materials to site in undamaged condition, in original containers or packages, complete with accessories and instructions. Label packages with manufacturer's name and brand designations. Package materials covered by specific references bearing specification number, type and class as applicable.

1.5.2 Storage

Store all materials in original protective packaging in a safe, dry, and clean location. Store panels at temperatures between 4 and 32 degrees C (40 and 90 degrees F), and between 20 and 70 percent humidity. Replace defective or damaged materials.

1.5.3 Handling

Materials shall be handled and protected in a manner to prevent damage during the entire construction period.

1.6 EXTRA MATERIALS

Furnish spare floor panels, complete pedestal assemblies, and stringers at the rate of one for each 100 or fraction thereof required.

PART 2 PRODUCTS

2.1 FLOOR PANELS

2.1.1 Floor System Drawings And Planer Quality

a. Submit Fabrication Drawings for elevated floor systems consisting of fabrication and assembly details to be performed in the factory.

b. Indicate on Location Drawings exact location of pedestals, ventilation openings, cable cutouts, and the panel installation pattern.

c. Provide Detail Drawings showing details of the pedestals, pedestal-floor interlocks, floor panels, panel edging, floor openings, floor opening edging, floor registers, floor grilles, cable cutout treatment, perimeter base, expansion joints, and peripheral support facilities.

d. Design and workmanship of the floor, as installed, shall be completely planar within plus or minus 1.5 mm in 3050 mm (0.060 inch in 10 feet), 2.5 mm (0.100 inch) for the entire floor, and 0.7 mm (0.030 inch) across panel joints.

e. Floor-panel joint-width tolerances shall be 0.43 mm (0.017 inch) as measured with a feeler gage at any point in any joint when the panels are in the pressure contact required in final installation and as long as the air leakage requirements above are met.

2.1.2 Panel Construction

a. Base access floor system on a 600 by 600 mm (24 by 24 inch) square module providing minimum of 150 mm (6 inch) clearance between structural floor and bottom of finished floor. Fabricate so accurate job cutting and fitting may be done using standard sizes for perimeters and around columns.

b. Do not expose metal on finished top surface of panels. Provide cutouts and cutout closures to accommodate utility systems and equipment intercabling. Reinforce cutouts to meet design load requirements. Provide extra support pedestals at each corner of cutout for cutout panels that do not meet specified design load requirements.

c. Panel design shall provide for convenient panel removal for underfloor servicing and for openings for new equipment. Use panels of uniform dimensions within specified tolerances. Permanently mark panels to indicate load rating and model number..

d. Machine square floor panels to within plus or minus 0.13 mm (0.005 inch) with edge straightness plus or minus 0.064 mm (0.0025 inch). Tolerances apply to the panel before the plastic edging is applied.

2.1.2.1 Aluminum

Provide aluminum panels of die-cast or extruded construction conforming to ASTM B85/B85M.

2.1.2.2 Hollow Formed Steel

Steel panels shall be of die-formed construction, consisting of a flat steel top sheet welded to one or more formed steel stiffener sheets or components. Panels shall be chemically cleaned, bonderized, and painted with the manufacturer's standard finish.

2.1.2.3 Metal-Clad Cementitious Fill (Composite Panels)

a. Provide composite panels of die-formed steel construction totally enclosing the panel, including the top surface. The void spaces between the top sheet and the formed steel bottom sheet shall be completely filled with an incombustible cementitious or concrete material. Seal cut edges in accordance with manufacturer's recommendations. Gravity held panels with bolted stringer understructure: Fasten end of each stringer and mid-point of each 1212 mm (4 foot) stringer positively to pedestal heads, using manufacturer's standard screws. Provide screws that are removable from top.

b. Grid supported panels shall be further tested by supporting them at two opposite edges and applying a 2225 newton (500-pound) load at the center of a panel selected; the panel shall be similarly tested while supported at the other two edges. Weld failure at any point under this loading is not acceptable. This additional test shall be applied to one panel per 46.45 square meter (500 square feet) of floor in the system, but in no case less than two panels. When any weld fails, the number of panels designated by the Contracting Officer shall be similarly tested; replace those panels that have a weld failure at no cost to the Government.

2.1.2.4 Metal-Clad Wood Core

Provide wood core panels with cores of wood particleboard conforming to CPA A208.1, Grade 1-M-3, or of plywood conforming to CPA A208.2, APA E30, and APA L870, EXT-DFPA-C-C. The core shall be not less than 25 mm (1 inch) thick, and be faced on both sides with structurally bonded zinc-coated steel sheets not lighter than 0.70 mm (24 gauge). All edges and corners shall be sealed with zinc-coated steel or extruded aluminum. The completed panels shall have a flame spread rating of 25 or less when tested in accordance with ASTM E84. Provide zinc-coated steel, extruded aluminum, fire resistant vinyl, or other fire resistant edging to protect shop and field edge cuts and cutouts through the face of panels in a manner to meet specified flame spread requirements.

2.1.2.5 Lightweight Concrete Panels

Provide lightweight concrete of lightweight structural concrete with either structural reinforcing or a die-formed, electro-galvanized steel bottom pan. All concrete surfaces, including those resulting from field cuts, shall be sealed with the manufacturer's standard sealer before covering the surfaces with other materials.

2.1.3 Floor Covering

Surface floor panels with materials firmly bonded in place with waterproof adhesive. The electrical resistance shall remain stable over the life expectancy of the floor covering. Any anti-static agent used in the manufacturing process shall be an integral part of the material, not surface applied. Bolt heads or similar attachments shall not rise above the traffic surface.

2.1.3.1 High Pressure Laminate

Provide high pressure laminate surfacing conforming to ANSI/NEMA LD 3, Grade HW 62 or 120. Total system electrical resistance from the wearing surface of the floor to the ground connection shall be between 150,000 ohms and 20,000,000,000 ohms.

2.1.3.2 Conductive Surfacing

Provide conductive surfacing conforming to ANSI/NEMA LD 3, Grade HW 62. The total system electrical resistance from the wearing surface of the floor to the ground connection shall be between 25,000 ohms and 1,000,000 ohms.

2.1.3.3 Conductive High Pressure Laminate

Conductive high pressure laminate floor surfacing shall conform to ASTM F1066, Type III, Vinyl Tile and UL 779. The total system electrical resistance from the wearing surface of the floor to the ground connection shall be between 25,000 ohms and 1,000,000 ohms.

2.1.3.4 Vinyl Composition Tile

Vinyl composition tile surfacing shall be 3 mm (1/8 inch) thick conforming to ASTM F1066, Type IV, Composition 1 or 2, or KS M 3802. Tiles may be approximately 300 mm (12 inches) square or may be the full size of the panel.

2.1.3.5 Carpet

Carpet surfacing shall be field installed using one full carpet square per panel. Carpet shall be nylon filament, loop pile, minimum 0.8 kg/square m (24 ounce/square yard), minimum density 4000, and without cushion. Conform color fastness to AATCC 16. Carpet shall conform to ASTM E648 with a minimum average critical radiant flux of 0.25 watts per square centimeter. Static control shall be less than 2.0 kV at 20 percent relative humidity at 21 degrees C (70 degrees F), when tested in accordance with AATCC 134. Provide vinyl edge trim to prevent unraveling.

2.1.4 Edge Strip

Edge panels with extruded vinyl edge strips secured in place with mechanical interlock or adhesive bond, or use replaceable type. Top of strip shall be approximately 3 mm (1/8 inch) wide, and flush with the floor surfacing. Metal edge strips exposed at finish floor surface will be rejected.

2.1.5 Accessories

Provide the manufacturer's standard registers, grilles, perforated panels, and plenum dividers type where indicated. Provide registers, grilles, and perforated panels designed to support the same static loads as floor panels without structural failure, and capable of delivering the air volumes indicated. Registers and perforated panels shall be 25 percent open area and equipped with adjustable dampers.

2.1.6 Resilient Base

Base shall be rubber or vinyl straight style (installed with carpet) or coved style (installed with resilient flooring), 150 mm (6 inches) high and a minimum 3 mm (1/8 inch) thick. Furnish Preformed offsite or Job Formed corners.

2.1.7 Lifting Device

Provide each individual room with one floor panel lifting device standard with the floor manufacturer. Furnish a minimum of two devices.

2.2 PANEL SUPPORT SYSTEM

Design support system to allow for 360 degree clearance in laying out cable and cutouts for service to machines and so that panel and stringer together take up maximum of 50 mm (2 inches).

2.2.1 Pedestals

Provide pedestals made of steel or aluminum or a combination thereof. Ferrous materials shall have a factory-applied corrosion-resistant finish. Provide pedestal base plates with a minimum of 10,300 square mm (16 square inches) of bearing surface and a minimum of 3 mm (1/8 inch) thickness. Pedestal shafts shall be threaded to permit height adjustment within a range of approximately 50 mm (2 inches), to permit overall floor adjustment within plus or minus 2.5 mm (0.10 inch) of the required elevation, and to permit leveling of the finished floor surface within 1.56 mm (0.062 inch) in 3000 mm (10 feet) in all directions. Provide locking devices to positively lock the final pedestal vertical adjustments in place. Pedestal caps shall interlock with panels or stringers to preclude tilting or rocking of the panels.

2.2.2 Stringers

Provide stringers of rolled steel or extruded aluminum, to interlock with the pedestal heads to prevent lateral movement. Provide stringers that can be added or removed after floor is in place.

2.3 FASCIA

Provide aluminum or steel fascia plates at open ends of floor, at sides of ramps and steps, and elsewhere as required to enclose the free area under the raised floor. Steel plates shall have a factory applied baked enamel finish. Finish on aluminum plates shall be standard with the floor system manufacturer. Fascia plates shall be reinforced on the back, and supported using the manufacturer's standard lateral bracing at maximum 1200 mm (4 feet) on center. Provide trim, angles, and fasteners as required.

2.4 STEPS AND RAMPS

Securely fasten steps and ramps to the access flooring system and to the structural floor. Include in the construction standard floor system components and custom components as required, and all supports, fasteners, and trim necessary for a finished installation. Step nosings, threshold strips, and floor bevel strips shall be cast or extruded aluminum with non-slip traffic surfaces. Submit certificate of compliance attesting that the installed access floor system meets specification requirements, including all special equipment loads and specific electrical and or cable requirements.

2.4.1 Steps

Height of risers shall not exceed 180 mm (7 inches). Design steps to support a uniform load of 7.18 kPa (150 psf). Surface treads with the manufacturer's standard non-slip floor finish.

2.4.2 Ramps

Slope of ramps shall not exceed 25 mm (1 inch) rise to 300 mm (12 inches) of run. Design ramps to support the same loads as specified for floor panels. Surface ramps with the manufacturer's standard non-slip floor finish.

2.5 RAILINGS

Provide railings of the double rail and post type, fabricated of at least 25 mm (1 inch) round seamless aluminum tubing with a satin natural anodized finish. At steps and ramps, make the top rail a minimum of 900 mm (36 inches) high and parallel to the incline. Make the top rail 1050 mm (42 inches) high at open ends of the floor. Guardrails shall have intermediate rails or an ornamental pattern such that a sphere 100 m (4 inches) in diameter cannot pass through. Space posts maximum of 1200 mm (4 feet) o.c. Provide railings complete with anchorages, floor plates, and end caps.

2.6 FACTORY TESTS

Factory test access flooring, using an independent laboratory, at the same position and maximum design elevation and in the same arrangement as shown on the drawings for installation so as to duplicate service conditions as much as possible.

2.6.1 Load Tests

Conduct floor panel, stringer, and pedestal testing in accordance with CISCA Access Floors.

2.6.2 Bond Strength of Covering

Support the test panel on pedestals and stringers as specified for the installed floor. Brace the supports as necessary to prevent sideways movement during the test. Impose a test load of 4.45 kN (1000 pounds) on the test assembly through a hard plastic caster 75 mm (3 inches) in diameter and 25 mm (1 inch)wide. Roll the caster completely across the center of the panel. The panel shall withstand 20 passes of the caster with no delamination or separation of the covering.

2.7 COLOR

Color shall be selected from manufacturers standard colors. Color listed is not intended to limit the selection of equal colors from other manufacturers.

2.8 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Install the floor system in accordance with the manufacturer's instructions and with the approved detail drawings. Open ends of the floor, where the floor system does not abut wall or other construction, shall have positive anchorage and rigid support. Maintain areas to receive access flooring between 4 and 32 degrees C (40 and 90 degrees F), and between 20 and 70 percent humidity for 24 hours prior to and during installation.

3.1.1 Preparation for Installation

Clear of all debris the area in which the floor system is to be installed. Thoroughly clean structural floor surfaces and remove all dust. Install floor coatings, required for dust or vapor control, prior to installation of pedestals, only if the pedestal adhesive will not damage the coating. If the coating and adhesive are not compatible, apply the coating after the pedestals have been installed and the adhesive has cured.

3.1.2 Pedestals

Pedestals shall be accurately spaced, and set plumb and in true alignment. Set base plates in full and firm contact with the structural floor, and secured to the structural floor with adhesive or steel expansion anchors.

3.1.3 Stringers

Interlock stringers with the pedestal caps to preclude lateral movement, spaced uniformly in parallel lines at the indicated elevation.

3.1.4 Auxiliary Framing

Provide auxiliary framing or pedestals around columns and other permanent construction, at sides of ramps, at open ends of the floor, and beneath panels that are substantially cut to accommodate utility systems. Use special framing for additional lateral support as shown on the approved detail drawings. Provide additional pedestals and stringers designed to specific heights and lengths to meet structural irregularities and design loads. Connect auxiliary framing to main framing.

3.1.5 Panels

Interlock panels with supports in a manner that will preclude lateral movement. Fasten perimeter panels, cutout panels, and panels adjoining columns, stairs, and ramps to the supporting components to form a rigid boundary for the interior panels. Floors shall be level within the specified tolerances. Cut edges panels shall be finished as recommended by the panel manufacturer. Secure extruded vinyl edging in place at all cut edges of all panel cut-outs to prevent abrasion of cables.

3.1.6 Resilient Base

Provide base at vertical wall intersections. Cracks and voids in walls and other vertical surfaces to receive base shall be filled with an approved filler. Apply the base after the floor system has been completely installed with adhesive, in accordance with the base manufacturer's recommendations.

3.1.7 Fascia Plates

Cover exposed floor ends and exposed openings of ramps and stairs with aluminum, steel closures, or finish material as indicated on the detailed drawings.

3.1.8 Repair of Zinc Coating

Repair zinc coating that has been damaged, and cut edges of zinc-coated components and accessories, by the application of a galvanizing repair paint conforming to ASTM A780/A780M. Areas to be repaired shall be thoroughly cleaned prior to application of the paint.

3.2 FIELD TESTS

Submit certified copies of test reports from an approved testing laboratory, attesting that the proposed floor system components meet the performance requirements specified.

3.2.1 Acceptance Tests

Conduct acceptance tests after installation of floor system. Make at least one test for each 100 square meters (1000 square feet) of floor area. Conduct tests in presence of Contracting Officer and representatives of manufacturer and installer. Submit certified copies of test reports from an approved testing laboratory, attesting that the proposed floor system components meet the performance requirements specified.

3.2.2 Electrical Resistance

Conduct testing of electrical resistance, in the completed installation, in the presence of the Contracting Officer in accordance with NFPA 99, modified by placing one electrode on the center of the panel surface and connecting the other electrode to the metal flooring support. Take measurements at five or more locations. Each measurement shall be the average of five readings of 15 seconds duration at each location. During the tests, relative humidity shall be 45 to 55 percent and temperature set at 21 to 24 degrees C (69 to 75 degrees F). Select panels used in the testing at random and include two panels most distant from the ground connection. Measure electrical resistance with instruments that are accurate within 2 percent and that have been calibrated within 60 days prior to the performance of the resistance tests. The metal-to-metal resistance from panel to supporting pedestal shall not exceed 10 ohms. The resistance between the wearing surface of the floor covering and the ground connection, as measured on the completed installation, shall be in accordance with paragraph FLOOR COVERING. Submit one hard copy & one digital copy (.pdf - text searchable) of electrical resistance test reports stating date of test, person conducting the test, results of test, and the area or areas tested.

3.3 CLEANING AND PROTECTION

3.3.1 Cleaning

Free of all debris the space below the completed floor. Before any traffic or other work on the completed raised floor is started, clean the completed floor in accordance with the floor covering manufacturer's instructions. Do not permit seepage of cleaner between individual panels. Cleaning of ferrous surfaces shall conform to FS TT-C-490.

3.3.2 Protection

Protect traffic areas of raised floor systems with a covering of building paper, fiberboard, or other suitable material to prevent damage to the surface. Cover cutouts with material of sufficient strength to support the loads to be encountered. Place plywood or similar material on the floor to serve as runways for installation of heavy equipment not in excess of design load capacity. Maintain protection until the raised floor system is accepted.

3.3.3 Surplus Material Removal

Clean surfaces of the work, and adjacent surfaces soiled as a result of the work. Remove all installation equipment, surplus materials, and rubbish from the work site.

3.4 FIRE SAFETY

Install an automatic detection system below the raised floor meeting the requirements of NFPA 75 paragraph 5-2.1 to sound an audible and visual alarm. Air space below the raised floor shall be subdivided into areas not exceeding 929 square meters (10,000 square feet) by tight, noncombustible bulkheads. Seal all penetrations for piping and cables to maintain bulkhead properties.

3.5 OPERATION AND MAINTENANCE MANUALS

Submit maintenance instructions for proper care of the floor panel surface. When conductive flooring is specified, also submit maintenance instructions to identify special cleaning and maintenance requirements to maintain "conductivity" properties of the panel finish.

-- End of Section --

SECTION 09 69 19

STRINGERLESS ACCESS FLOORING
11/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC 134	(2011) Electrostatic Propensity of Carpets
AATCC 16	(2004; E 2008; E 2010) Colorfastness to Light

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E30	(2011) Engineered Wood Construction Guide
APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B85/B85M	(2010) Standard Specification for Aluminum-Alloy Die Castings
ASTM E648	(2010; E 2011) Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1066	(2004; E 2010; R 2010) Standard Specification for Vinyl Composition Floor Tile

CEILINGS AND INTERIOR SYSTEMS CONSTRUCTION ASSOCIATION (CISCA)

CISCA Access Floors	(2007) Recommended Test Procedures for Access Floors

COMPOSITE PANEL ASSOCIATION (CPA)

CPA A208.1	(2009) Medium Density Fiberboard (MDF) For Interior Applications

CPA A208.2	(2009) Medium Density Fiberboard (MDF) for Interior Applications

ICC EVALUATION SERVICE, INC. (ICC-ES)

ICC-ES AC300	(2009) Acceptance Criteria for Access Floors

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2012) International Building Code

KOREAN INDUSTRIAL STANDARDS (KS)

KS M 3802	(2008) Floor Covering - PVC

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA LD 3	(2005) Standard for High-Pressure Decorative Laminates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 75	(2013) Standard for the Protection of Information Technology Equipment
NFPA 99	(2015) Health Care Facilities Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-C-490	(Rev E) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings

UNDERWRITERS LABORATORIES (UL)

UL 779	(2011) Standard for Electrically Conductive Floorings

1.2 SYSTEM DESCRIPTION

Install access flooring at the location and elevation, and in the arrangement shown on the drawings. The floor system shall be of the stringerless type, complete with all supplemental items, and be the standard product of a manufacturer specializing in the manufacture of access flooring systems.

a. Provide for self-alignment of floor panels, adjustable pedestals and readily removable floor panels covered as specified.

b. Make lateral stability of floor support system integral with panels. Finished assembly shall be stable and free of vibration, noises, and rocking panels. If indicated on contract drawings, provide stringerless system with equipotential plane grounding.

c. Submit certificate of compliance attesting that the installed access floor system meets specification requirements, including all special equipment loads and specific electrical and or cable requirements, and certificates for the complete Access Flooring System including, but not limited to the following:

(1) Submit design data substantiating Compliance with ICC-ES AC300.(International Building Code Acceptance Criteria for Access Floors.)

(2) Load-bearing capabilities of pedestals, floor panels, and pedestal adhesive resisting force.

(3) Supporting independent laboratory test reports. For panel loads, test results include concentrated loads at center of panel, panel edge midpoint, ultimate loads and uniform loads.

(4) Floor electrical characteristics.

(5) Material requirements

(6) Elevated floor system free of defects in materials, fabrication, finish, and installation for a period of not less than 10 years after completion.

d. The Contractor warrants that, upon notification by the Government, defective work will be immediately replaced with new work at no additional cost to the Government.

e. Submit manufacturer's descriptive data, catalog cuts, and installation instructions including information about any design and production techniques, total system including all accessories and finish coatings of under-floor components, procedures and policies used to conserve energy, reduce material, improve waste management or incorporate green building/recycled products into the manufacturer of their components or products. Also include cleaning and maintenance instructions. Systems which contain zinc electroplated anti-corrosion coatings are prohibited.

1.2.1 Floor Panel Allowable Tolerances

a. Flatness: Plus or minus 0.5 mm (0.02 inches) on diagonal on top of panel or underneath edge.

b. Length: Plus or minus 0.4 mm (0.015 inch).

c. Squareness: Plus or minus 0.5 mm (0.02 inch) in panel length.

d. Finish Floor: Level within plus or minus 1.6 mm in 2 m (0.062 inch) in 10 feet), and plus or minus 2.5 mm (0.10 inch) for entire floor.

1.2.2 Floor Panels

Conduct floor panel testing in accordance with CISCA Access Floors. When tested as specified, make all deflection and deformation measurements at the point of load application on the top surface of the panel. Floor panels shall be capable of supporting the following loads, unless otherwise indicated on contract drawings:

a. Concentrated load of 5560 N (1250 pounds) on 645 square mm (one square inch), at any point on panel, without a top-surface deflection more than 2.54 mm (0.10 inch), and a permanent set not to exceed 0.25 mm (0.01 inch) in any of the specified tests.

b. Uniform live load of 14.36 kPa/square meter (300 psf), without a top-surface deflection more than 1.5 mm (0.06 inch), and a permanent set not to exceed 0.25 mm (0.01 inch) in any of the specified tests.

c. A rolling load of 4450 N (1000 pounds) applied through hard rubber surfaced wheel 150 mm (6 inch) diameter by 50 mm (2 inch) wide for 10,000 cycles over the same path. Permanent set at conclusion of test shall not exceed 1.0 mm (0.040 inch).

d. A rolling load of 5560 N (1250 pounds) applied through a 75 mm (3 inch) diameter by 30 mm (1-13/16 inch) wide caster for 10 cycles over the same path, without developing a local overall surface deformation greater than 1 mm (0.04 inch). In accordance with CISCA Access Floors, the permanent deformation limit under rolling load shall be satisfied in all of the specified tests.

e. An impact load of 670 N (150pounds) anywhere on the panel dropped from a height of 914 mm (36 inches) onto a 645 square mm (1 square inch) area without failure of the system, according to CISCA Access Floors, Section 8 Drop Impact Load Test.

f. Ultimate Concentrated Load. Panels shall provide a safety factor of 3 times the specified concentrated load indicated above, when tested in accordance with CISCA Access Floors, Section 2 Ultimate Loading.

1.2.3 Pedestals

Provide pedestals capable of supporting a 22.24 kN (5000 pound) axial load without permanent deformation.

1.2.4 Bonding Strength of Pedestal Adhesive

Adhesive for anchoring pedestal bases shall have a bonding strength capable of resisting an overturning moment of 113 Nm (1,000 lbf-in) when a force is applied to the top of the pedestal in any direction.

1.2.5 Bond Strength of Factory Installed Covering

Bond strength of floor covering shall be sufficient to permit handling of the panels by use of the panel lifting device, and to withstand moving caster loads up to 4.45 kN (1000 pounds), without separation of the covering from the panel.

1.2.6 Seismic Calculations

1.2.6.1 Army Requirements

Submit design calculations for special bracing to resist the effects of seismic or other forces and demonstrate that the proposed floor system meets specified requirements in accordance with UFC 3-310-04, ICC IBC and ICC-ES AC300 . Certified copies of test reports may be submitted in lieu of calculations.

1.2.7 Air Leakage

When the space below the finished floor system is an air plenum, air leakage through the joints between panels and around the perimeter of the floor system shall not exceed 0.15 L/s of air per linear meter (0.1 cubic foot of air per minute per linear foot) of joint subjected to 2.5 mm (0.1 inch), water gauge, positive pressure in the plenum. Measure the leakage rate on the finished raised floor system, which may include carpet.

1.2.8 Grounding

Ground the access flooring system for safety hazard and static suppression. Provide positive contact between components for safe, continuous electrical grounding of entire floor system. Total system resistance from wearing surface of floor to building grounding electrode shall be within range of 0.025 to 1.0 megohms, unless otherwise indicated.

1.2.8.1 Metal Grilles

Exposed metal is not allowed at wearing surface of access floor system, except at metal grilles and registers. When grilles and metal registers are provided, insulate as required to provide same grounding resistance as wearing surface.

1.2.8.2 Joint Resistance

Electrical resistance, between pedestals and floor panels as mounted in normal use, shall be less than 3 ohms.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Installation Drawings; G

SD-03 Product Data

Access Flooring System

SD-05 Design Data

Compliance with ICC-ES AC300
Seismic Calculations

SD-06 Test Reports

Electrical Resistance
Acceptance Tests

SD-07 Certificates

Certificate Of Compliance

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

Submit drawings showing location, details at floor perimeter, method of anchorage to structural subfloor, grounding, description of shop or factory coating, installation height above structural floor, stairs, ramps, accessories, other details as specified and take measurements from finished areas at site and submit detailed installation drawings indicating:

a. Location of panels.

b. Layout of supports, panels, and cutout locations.

c. Stair, handrail, and ramp framing.

d. Sizes and details of components.

e. Lateral bracing.

f. Typical cutout details.

g. Gasketing, return air grilles, supply air registers, and perforated panels. Include air transfer capacity of grilles, registers and panels.

h. Floor finishes.

i. Location of connection to building grounding electrode.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver materials to site in undamaged condition, in original containers or packages, complete with accessories and instructions. Label packages with manufacturer's name and brand designations. Package materials covered by specific references bearing specification number, type and class as applicable.

1.5.2 Storage

Store all materials in original protective packaging in a safe, dry, and clean location. Store panels at temperatures between 4 and 32 degrees C (40 and 90 degrees F), and between 20 and 70 percent humidity. Replace defective or damaged materials.

1.5.3 Handling

Handle and protect materials in a manner to prevent damage during the entire construction period.

1.6 EXTRA MATERIALS

Furnish spare floor panels and spare complete pedestal assemblies at the rate of one for each 100 or fraction thereof required.

PART 2 PRODUCTS

2.1 FLOOR PANELS

2.1.1 Floor System Drawings And Planer Quality

a. Submit Fabrication Drawings for elevated floor systems consisting of fabrication and assembly details to be performed in the factory.

b. Indicate on Location Drawings exact location of pedestals, ventilation openings, cable cutouts, and the panel installation pattern.

c. Provide Detail Drawings showing details of the pedestals, pedestal-floor interlocks, floor panels, panel edging, floor openings, floor opening edging, floor registers, floor grilles, cable cutout treatment, perimeter base, expansion joints, and peripheral support facilities.

d. Design and workmanship of the floor, as installed, shall be completely planar within plus or minus 1.5 mm in 3050 mm (0.060 inch in 10 feet), 2.5 mm (0.100 inch) for the entire floor, and 0.7 mm (0.030 inch) across panel joints.

e. Floor-panel joint-width tolerances shall be 0.43 mm (0.017 inch) as measured with a feeler gage at any point in any joint when the panels are in the pressure contact required in final installation and as long as the air leakage requirements above are met.

2.1.2 Panel Construction

a. Base access floor system on a 600 by 600 mm (24 by 24 inch) square module providing minimum of 150 mm (6 inch) clearance between structural floor and bottom of finished floor. Fabricate so accurate job cutting and fitting may be done using standard sizes for perimeters and around columns.

b. Do not expose metal on finished top surface of panels. Provide cutouts and cutout closures to accommodate utility systems and equipment intercabling. Reinforce cutouts to meet design load requirements. Provide extra support pedestals at each corner of cutout for cutout panels that do not meet specified design load requirements.

c. In the panel design provide for convenient panel removal for underfloor servicing and for openings for new equipment. Use panels of uniform dimensions within specified tolerances. Permanently mark panels to indicate load rating and model number.

d. Machine square floor panels to within plus or minus 0.13 mm (0.005 inch) with edge straightness plus or minus 0.064 mm (0.0025 inch). Tolerances apply to the panel before the plastic edging is applied.

2.1.2.1 Aluminum

Provide aluminum panels of die-cast or extruded construction conforming to ASTM B85/B85M.

2.1.2.2 Hollow Formed Steel

Provide steel panels of die-formed construction, consisting of a flat steel top sheet welded to one or more formed steel stiffener sheets or components. Panels shall be chemically cleaned, bonderized, and painted with the manufacturer's standard finish.

2.1.2.3 Metal-Clad Cementitious Fill (Composite Panels)

Provide composite panels of die-formed steel construction totally enclosing the panel, including the top surface. The void spaces between the top sheet and the formed steel bottom sheet shall be completely filled with an incombustible cementitious or concrete material. Seal cut edges in accordance with manufacturer's recommendations.

2.1.2.4 Metal-Clad Wood Core

Provide wood core panels with cores of wood particleboard conforming to CPA A208.1, Grade 1-M-3, or of plywood conforming to CPA A208.2 , APA E30, and APA L870, EXT-DFPA-C-C, not less than 25 mm (1 inch) thick, and faced on both sides with structurally bonded zinc-coated steel sheets not lighter than 0.70 mm (24 gauge). Seal all edges and corners with zinc-coated steel or extruded aluminum. The completed panels shall have a flame spread rating of 25 or less when tested in accordance with ASTM E84. Provide zinc-coated steel, extruded aluminum, fire resistant vinyl, or other fire resistant edging to protect shop and field edge cuts and cutouts through the face of panels in a manner to meet specified flame spread requirements.

2.1.2.5 Lightweight Concrete Panels

Provide lightweight concrete panels of lightweight structural concrete with either structural reinforcing or a die-formed, electro-galvanized steel bottom pan. Seal all concrete surfaces, including those resulting from field cuts, with the manufacturer's standard sealer before covering the surfaces with other materials.

2.1.3 Floor Covering

Surface floor panels with materials firmly bonded in place with waterproof adhesive. The electrical resistance shall remain stable over the life expectancy of the floor covering. Any anti-static agent used in the manufacturing process shall be an integral part of the material, and not surface applied. Bolt heads or similar attachments shall not rise above the traffic surface.

2.1.3.1 High Pressure Laminate

Provide high pressure laminate surfacing conforming to ANSI/NEMA LD 3, Grade HW 62 or 120. Total system electrical resistance from the wearing surface of the floor to the ground connection shall be between 150,000 ohms and 20,000,000,000 ohms.

2.1.3.2 Conductive Surfacing

Provide conductive surfacing conforming to ANSI/NEMA LD 3, Grade HW 62. The total system electrical resistance from the wearing surface of the floor to the ground connection shall be between 25,000 ohms and 1,000,000 ohms.

2.1.3.3 Conductive High Pressure Laminate

Provide conductive high pressure laminate floor surfacing conforming to ASTM F1066, Type III, Vinyl Tile and UL 779. The total system electrical resistance from the wearing surface of the floor to the ground connection shall be between 25,000 ohms and 1,000,000 ohms.

2.1.3.4 Vinyl Composition Tile

Vinyl composition tile surfacing shall be 3 mm (1/8 inch) thick conforming to ASTM F1066, Type IV, Composition 1 or 2, or KS M 3802. Tiles may be approximately 300 mm (12 inches) square or may be the full size of the panel.

2.1.3.5 Carpet

Carpet surfacing shall be field installed using one full carpet square per panel. Provide carpet of nylon filament, loop pile, minimum 0.8 kg/square m (24 ounce per square yard), minimum density 4000, and without cushion. Color fastness shall conform to AATCC 16. Carpet shall conform to ASTM E648 with a minimum average critical radiant flux of 0.25 watts per square centimeter, and static control less than 2.0 kV at 20 percent relative humidity at 21 degrees C (70 degrees F), when tested in accordance with AATCC 134. Provide vinyl edge trim to prevent unraveling.

2.1.4 Edge Strip

Provide panels edged with extruded vinyl edge strips secured in place with mechanical interlock or adhesive bond, or be of a replaceable type. Top of strip shall be approximately 3 mm (1/8 inch) wide, and flush with the floor surfacing. Metal edge strips exposed at finish floor surface will be rejected.

2.1.5 Accessories

Provide the manufacturer's standard type registers, grilles, perforated panels, and plenum dividers where indicated, designed to support the same static loads as floor panels without structural failure, and capable of delivering the air volumes indicated. Registers and perforated panels shall be 25 percent open area and equipped with adjustable dampers.

2.1.6 Resilient Base

Base shall be rubber or vinyl straight style (installed with carpet) or coved style (installed with resilient flooring), 150 mm (6 inches) high and a minimum 3 mm (1/8 inch) thick. Furnish corners preformed off site or job Formed.

2.1.7 Lifting Device

Provide each individual room with one floor panel lifting device standard with the floor manufacturer. Furnish a minimum of two devices.

2.2 PANEL SUPPORT SYSTEM

Design panel and pedestal support system to allow for 360 degree clearance in laying out cable and cutouts for service to machines. Provide pedestals of steel or aluminum or a combination thereof. Ferrous materials shall have a factory-applied corrosion-resistant finish. Provide pedestal base plates with a minimum of 10,300 square mm (16 square inches) of bearing surface and a minimum of 3 mm (1/8 inch) thick. Pedestal shafts shall be threaded to permit height adjustment within a range of approximately 50 mm (2 inches), to permit overall floor adjustment within plus or minus 2.5 mm (0.10 inch) of the required elevation, and to permit leveling of the finished floor surface within 1.56 mm (0.062 inch) in 3000 mm (10 feet) in all directions. Provide locking devices to positively lock the final pedestal vertical adjustments in place. Pedestal caps shall interlock with panels to preclude tilting or rocking of the panels. Submit one sample of each panel type and suspension system proposed for use.

2.3 FASCIA

Provide aluminum or steel fascia plates at open ends of floor, at sides of ramps and steps, and elsewhere as required to enclose the free area under the raised floor. Steel plates shall have a factory applied baked enamel finish. Finish on aluminum plates shall be standard with the floor system manufacturer. Provide fascia plates reinforced on the back, and supported using the manufacturer's standard lateral bracing at maximum 1200 mm (4 feet) on center. Provide trim, angles, and fasteners as required.

2.4 STEPS AND RAMPS

Securely fasten steps and ramps to the access flooring system and to the structural floor. Perform construction including standard floor system components and custom components as required, and all supports, fasteners, and trim necessary for a finished installation. Provide step nosings, threshold strips, and floor bevel strips made of cast or extruded aluminum with non-slip traffic surfaces.

2.4.1 Steps

Height of risers shall not exceed 180 mm (7 inches). Design steps to support a uniform load of 7.18 kPa (150 psf). Surface treads with the manufacturer's standard non-slip floor finish.

2.4.2 Ramps

Slope of ramps shall not exceed 25 mm (1 inch) rise to 300 mm (12 inches) of run. Design ramps to support the same loads as specified for floor panels. Surface ramps with the manufacturer's standard non-slip floor finish.

2.5 RAILINGS

Provide railings of the double rail and post type, fabricated of at least 25 mm (1 inch) round seamless aluminum tubing with a satin natural anodized finish. At steps and ramps, the top rail shall be a minimum of 900 mm (36 inches) high and parallel to the incline. Keep the top rail 1050 mm (42 inches) high at open ends of the floor. Provide guardrails with intermediate rails or an ornamental pattern such that a sphere 100 m (4 inches) in diameter cannot pass through. Space posts maximum of 1200 mm (4 feet) on center. Provide railings complete with anchorages, floor plates, and end caps. If indicated on contract drawings, electronically ground hand rails to raised floor system to prevent static build-up.

2.6 FACTORY TESTS

Access flooring shall be factory tested by an independent laboratory, at the same position and maximum design elevation and in the same arrangement as shown on the drawings, for installation so as to duplicate service conditions as much as possible.

2.6.1 Load Tests

Conduct floor panel and pedestal testing in accordance with CISCA Access Floors.

2.6.2 Bond Strength of Covering

Support the test panel on pedestals as specified for the installed floor. Brace the pedestal supports as necessary to prevent sideways movement during the test. Impose a test load of 4.45 kN (1000 pounds) on the test assembly through a hard plastic caster 75 mm (3 inches) in diameter and 25 mm (1 inch) wide. Roll the caster completely across the center of the panel. The panel shall withstand 20 passes of the caster with no delamination or separation of the covering.

2.7 COLOR

Color shall be as indicated on contract drawings, selected from manufacturer's standard colors. Color listed is not intended to limit the selection of equal colors from other manufacturers.

2.8 REGISTERS AND GRILLES

Registers and grilles length and area shall be as indicated. Material shall be extruded aluminum , in mill finish, to sustain point loads of 1100 newton (250 pounds) per vane without failure or permanent deformation. No part of a grille may project more than 3 mm (1/8 inch) above the floor. Registers and grills are not permitted in a laminate floor tile system.

2.9 PERFORATED AIR SUPPLY PANELS

Provide air supply floor panels meeting the design criteria specified for standard panels, fabricated of 2 mm (14-gage) perforated steel sheet welded to minimum 1.6 mm (16-gage) side channels, covered with plastic laminate to match standard panels, and have a uniform perforated pattern to allow even air distribution

2.10 CUT OUTS

a. Provide cable cutouts finished with rigid polyvinylchloride or molded polypropylene edging to conform to the appearance level of the floor surface and to cover raw edges of the cutout panel. Extrusion shall be of a configuration to permit its effective and convenient use when new cable openings are required. Provide at least 7300 mm (24 feet) of additional extrusion for future use.

b. Provide non-metallic adapter for openings less than 100 mm (4 inches) wide. Secure adapter adhesively in cutout to preclude removal from panel. Provide at least two adapters per 10 square m (1000 square feet) for future use.

c. Openings larger than 100 mm (4 inches) wide shall use rigid polyvinylchloride or molded polypropylene edging. Perform cutting of panels, including cutouts, outside of the building.

2.11 EDGE CLOSURE

Provide 1.5 mm (1/16 inch) aluminum closure plate and extruded aluminum nosing at exposed edge of floor. Back up the closure plates with aluminum or steel framing braced diagonally, or anchor at bottom to continuous angle.

2.12 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Install the floor system in accordance with the manufacturer's instructions and with the approved detail drawings. At open ends of the floor, where the floor system does not abut wall or other construction, provide positive anchorage and rigid support. Areas to receive access flooring shall be maintained between 4 and 32 degrees C (40 and 90 degrees F), and between 20 and 70 percent humidity for 24 hours prior to and during installation.

3.1.1 Preparation for Installation

Clear of all debris the area in which the floor system is to be installed. Remove all dust and thoroughly clean structural floor surfaces. Install floor coatings required for dust or vapor control prior to installation of pedestals, only if the pedestal adhesive will not damage the coating. If the coating and adhesive are not compatible, apply the coating after the pedestals have been installed and the adhesive has cured.

3.1.2 Pedestals

Pedestals shall be accurately spaced, set plumb and in true alignment. Set base plates in full and firm contact with the structural floor, secured to the structural floor with adhesive or steel expansion anchors.

3.1.3 Auxiliary Framing

Provide auxiliary framing or pedestals around columns and other permanent construction, at sides of ramps, at open ends of the floor, and beneath panels that are substantially cut to accommodate utility systems. Provide special framing for additional lateral support as shown on the approved detail drawings. Provide additional pedestals designed to specific heights and lengths to meet structural irregularities and design loads. Connect auxiliary framing to main framing.

3.1.4 Panels

Interlock panels with supports in a manner that will preclude lateral movement. Fasten perimeter panels, cutout panels, and panels adjoining columns, stairs, and ramps to the supporting components to form a rigid boundary for the interior panels. Floors shall be level within the specified tolerances. Cut edges of steel and wood-core panels shall be painted or finished as recommended by the panel manufacturer. Cut edges of composite panels shall be coated with a silicone rubber sealant or with an adhesive recommended by the panel manufacturer. Secure extruded vinyl edging in place at all cut edges of all panel cut-outs to prevent abrasion of cables. Where the space below the floor is a plenum, cutouts for conduit and similar penetrations shall be closed using self-extinguishing sponge rubber.

3.1.5 Resilient Base

Provide base at vertical wall intersections. Fill cracks and voids in walls and other vertical surfaces to receive base with an approved filler. Apply the base after the floor system has been completely installed with adhesive in accordance with the base manufacturer's recommendations.

3.1.6 Fascia Plates

Cover exposed floor ends and exposed openings of ramps and stairs with aluminum, steel closures, or finish material as indicated on the detailed drawings.

3.1.7 Repair of Zinc Coating

Repair zinc coating that has been damaged, and cut edges of zinc-coated components and accessories, by the application of a galvanizing repair paint conforming to ASTM A780/A780M. Thoroughly clean areas to be repaired prior to application of the paint.

3.2 FIELD TESTS

3.2.1 Acceptance Tests

Conduct acceptance tests after installation of floor system. Make at least one test for each 100 square meters (1000 square feet) of floor area. Conduct tests in presence of Contracting Officer and representatives of manufacturer and installer. Submit certified copies of test reports from an approved testing laboratory, attesting that the proposed floor system components meet the performance requirements specified.

3.2.2 Electrical Resistance

Conduct testing of electrical resistance in the completed installation in the presence of the Contracting Officer. Perform testing in accordance with NFPA 99 modified by placing one electrode on the center of the panel surface and connecting the other electrode to the metal flooring support. Take measurements at five or more locations. Each measurement shall be the average of five readings of 15 seconds duration at each location. During the tests, relative humidity shall be 45 to 55 percent and temperature 21 to 24 degrees C (69 to 75 degrees F). Select panels used in the testing at random and include two panels most distant from the ground connection. Measure electrical resistance with instruments that are accurate within 2 percent and that have been calibrated within 60 days prior to the performance of the resistance tests. The metal-to-metal resistance from panel to supporting pedestal shall not exceed 10 ohms. The resistance between the wearing surface of the floor covering and the ground connection, as measured on the completed installation, shall be in accordance with paragraph FLOOR COVERING. Submit one hard copy & one digital copy (.pdf - text searchable) of electrical resistance test reports stating date of test, person conducting the test, results of test, and the area or areas tested.

3.3 CLEANING AND PROTECTION

3.3.1 Cleaning

Keep the space below the completed floor free of all debris. Before any traffic or other work on the completed raised floor is started, clean the completed floor in accordance with the floor covering manufacturer's instructions. Do not permit seepage of cleaner between individual panels. Cleaning of ferrous surfaces shall conform to FS TT-C-490.

3.3.2 Protection

Protect traffic areas of raised floor systems with a covering of building paper, fiberboard, or other suitable material to prevent damage to the surface. Cover cutouts with material of sufficient strength to support the loads to be encountered. Place plywood or similar material on the floor to serve as runways for installation of heavy equipment not in excess of design load capacity. Maintain protection until the raised floor system is accepted.

3.3.3 Surplus Material Removal

Clean surfaces of the work, and adjacent surfaces soiled as a result of the work. Remove all installation equipment, surplus materials, and rubbish from the work site.

3.4 FIRE SAFETY

If indicated in contract drawings, install an automatic detection system, below the raised floor, meeting the requirements of NFPA 75 paragraph 5-2.1 to sound an audible and visual alarm. Air space below the raised floor shall be subdivided into areas not exceeding 929 square meters (10,000 square feet) by tight, noncombustible bulkheads. Seal all penetrations for piping and cables to maintain bulkhead properties.

3.5 OPERATION AND MAINTENANCE MANUALS

Submit maintenance instructions for proper care of the floor panel surface. When conductive flooring is specified, also submit maintenance instructions to identify special cleaning and maintenance requirements to maintain "conductivity" properties of the panel finish.

-- End of Section --

SECTION 09 72 00

WALLCOVERINGS
11/12

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C423	(2009a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

GYPSUM ASSOCIATION (GA)

GA 214	(2010) Recommended Levels of Gypsum Board Finish

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2012) International Building Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 265	(2011) Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Coverings on Full Height Panels and Walls
NFPA 286	(2011) Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS CCC-W-408	(Rev D; Notices 1, 2) Wallcovering, Vinyl Coated

UNDERWRITERS LABORATORIES (UL)

UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wallcoverings and Accessories; G
Primer and Adhesive

SD-07 Certificates

Manufacturer's Statement

SD-10 Operation and Maintenance Data

Manufacturer's Maintenance Instructions

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver the material to the site in manufacturer's original wrappings and packages and clearly label with the manufacturer's name, brand name, pattern and color name and number, dye lot number, size, and other related information. Store in a safe, dry, clean, and well-ventilated area at temperatures not less than 10 degrees C (50 degrees F) and within a relative humidity range of 30 to 60 percent. Store wallcovering material in a flat position and protected from damage, soiling, and moisture. Do not open containers until needed for installation, unless verification inspection is required.

1.4 ENVIRONMENTAL REQUIREMENTS

Comply with wallcovering manufacturer's printed installation instructions for minimum temperature of area to receive requirements for conditioning adhesive and wallcovering. Provide a minimum 10 degrees C (50 degrees F) area temperature, 72 hours prior to installation, during installation, and until the adhesive dries. Observe ventilation and safety procedures.

1.5 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a one-year period.

1.6 EXTRA MATERIALS

Provide one linear meter (foot) of full-width wallcovering of each pattern and color for each 100 linear meters (100 linear feet) of wallcovering installed. Provide the same manufacturer, type, pattern, color, and lot number of extra stock as the installed wallcovering. Provide full rolls, packed for storage and marked with content, manufacturer's name, pattern and color name and number and dye lot number. Leave extra stock at the site at a location as directed by the Contracting Officer.

PART 2 PRODUCTS

2.1 WALLCOVERINGS AND ACCESSORIES

Provide wall coverings and accessories material designed specifically for the specified use. Furnish vinyl wallcovering and borders with a mercury, cadmium, lead, and chromium free base. Protect wallcoverings with bactericides and mildew inhibitors against microbiological and mildew growth.

2.1.1 Product Data

a. Wallcovering: Submit manufacturer's descriptive data, documenting physical characteristics, flame resistance, mildew and germicidal characteristics for wallcovering.

b. Accessories: Submit manufacturer's descriptive data for corner guard and wainscot cap.

c. Primer and Adhesive: Submit manufacturer's descriptive data, documenting physical characteristics, mildew and germicidal characteristics.

2.1.2 Certificates

Submit manufacturer's statement attesting that the product furnished meets or exceeds specification requirements. Date the statement after the award of the contract, state Contractor's name and address, name the project and location, and list the requirements being certified. Include these certificates:

(1) Certified laboratory test reports of the physical properties for vinyl wallcovering, as specified.

(2) Certificates of Compliance for UL fire hazard classification listing, as specified.

(3) Certificates of Compliance for contact adhesive.

2.1.3 Manufacturer's Instructions

Submit preprinted installation instructions for wallcovering and accessories, adhesives and primers. Include substrate preparation and material application in the instructions.

2.1.4 Operations and Maintenance Data

a. Submit Data Package 1 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

b. Submit one hard copy & one digital copy (.pdf - text searchable) of manufacturer's maintenance instructions for each type of vinyl wallcovering and accessory describing recommended type of cleaning equipment and materials, spotting and cleaning methods, and cleaning cycles. Instructions to also include preventative maintenance, recommended cleaning materials and precautions in the use of cleaning materials that may be detrimental to the wallcovering surface and accessories when improperly applied.

2.2 VINYL WALLCOVERING

Provide a vinyl coated woven or nonwoven wallcovering fabric. Conform to FS CCC-W-408 for vinyl wallcovering, Type I (Light Duty) with a minimum total weight of 339 grams/square meter (10 ounces/square yards) and 465 grams/linear meter (15 ounces/linear yards), or Type II (Medium Duty) with a minimum total weight of 441 grams/square meter (13 ounces/square yards) and 620 grams/linear meter (20 ounces/linear yards), or Type III (Heavy Duty) with a minimum total weight of 746 grams/square meter (22 ounces/square yards) and 1023 grams/linear meter (33 ounces/linear yards). Provide width of 1320/1371 mm (52/54 inch). Test vinyl wallcovering in accordance with NFPA 286 or meet the requirements of Class A when tested in accordance with ASTM E84 or UL 723.

2.3 TEXTILE WALLCOVERING

Provide colorfast, stain, and soil resistant textile wallcovering fabricated of woven fabric with paper or acrylic backing. Test in accordance with NFPA 265 or NFPA 286. Meet the requirements of Class A when tested in accordance with ASTM E84 or UL 723. Comply with or exceed the following for textile wallcovering:

a. Face fiber content: Wool, linen, cotton, rayon, or jute.

b. Weave: Plain

c. Total weight: As indicated in contract drawings.

d. Width: As indicated in contract drawings.

2.4 ACOUSTICAL WALLCOVERING

Provide acoustical wallcovering fabricated of synthetic material or vinyl coated fabric with porous surface with fused back. Test in accordance with NFPA 265 or NFPA 286. Meet the requirements of Class A when tested in accordance with ASTM E84 or UL 723. Comply with or exceed the following for textile wallcovering:

a. Total weight: As indicated in contract drawings.

b. Width: As indicated in contract drawings.

c. NRC rating in accordance with ASTM C423: As indicated in contract drawings.

2.5 WALLCOVERING BORDER

Provide wallcovering border of nonwoven vinyl cellulose/polyester blend or vinyl coated strippable paper back. Comply with or exceed the following for wallcovering border:

a. Total weight: As indicated in contract drawings.

b. Width: As indicated in contract drawings.

2.6 PRESENTATION DRY ERASE WALLCOVERING

Furnish presentation dry erase wallcovering that accepts dry erase markings and is designed to be used as a projection screen. Provide wallcovering with a minimum total weight of 678 g/square meter (20 ounces/square yards), a width of 1524 mm (60 inch) and backing of a woven or nonwoven polyester. Test wallcovering in accordance with NFPA 286 or have a Class A flame spread rating of 0-25 and smoke development rating of 0-450 when tested in accordance with ASTM E84 or UL 723. Provide wallcovering color white, unless otherwise indicated. When frame is required provide aluminum or oak and have a full length tray of the same material. Markings shall be removable with a felt eraser or cloth without ghosting. Provide each unit complete with an eraser, four different color compatible dry erase markers, and a 240 ml (an 8 ounce) bottle of liquid surface cleaner recommended by the manufacturer.

2.7 WALL LINER

Provide a non-woven polyester cellulose blend wall liner having a minimum weight of 125 g/square meter (3.7 ounces/square yards) and a total minimum thickness of 0.33 mm (0.013 inch). Test wall liner in accordance with NFPA 286 or have a Class A flame spread rating of 0-25 and smoke development rating of 0-450 when tested in accordance with ASTM E84 or UL 723.

2.8 CORNER GUARDS

Furnish 2 mm (0.075 inch) thick corner guards 28 mm (1-1/8 inch) each side of corner at right angles. Provide clear polycarbonate vinyl or rubber corner guards from the same color lot.

2.9 WAINSCOT CAP

Provide satin-finished extruded aluminum wainscot cap 19 mm (3/4 inch) high, feathered at bottom edge, with 5 mm (3/16 inch) exposed face on top edge, and grooved to receive the covering.

2.10 PRIMER AND ADHESIVE

Provide a type primer and adhesive recommended by the wallcovering manufacturer, containing a non-mercury based mildewcide, and complying with local indoor air quality standards. Primer shall permit removal of the wallcovering and protect the wall surface during removal. Do not damage gypsum wallboard facing paper during removal of wallcovering. Provide a strippable type adhesive. When substrate color variations show through vinyl wallcovering, provide a white pigmented primer as recommended by the wallcovering manufacturer used to conceal the variations. Provide a recommended type adhesive to install corner guards and wainscot cap by the manufacturer of the corner guards and wainscot cap.

2.11 COLOR, TEXTURE, AND PATTERN

Provide color, texture and pattern in accordance with selected from manufacturers standard colors. Color listed is not intended to limit the selection of equal colors from other manufacturers.

2.12 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

Inspect all areas and conditions under which wallcoverings are to be installed. Notify the Contracting Officer, in writing, of any conditions detrimental to the proper and timely completion of the installation. Work will proceed only when conditions have been corrected and accepted by the installer.

3.2 SURFACE PREPARATION

Do not apply wallcovering to surfaces that are rough, that contain stains which will bleed through the wallcovering, or that are otherwise unsuitable for proper installation. Fill cracks and holes; sand rough spots smooth. Finish walls to receive presentation dry erase wallcovering to a Level 4 gypsum wallboard finish in accordance with GA 214 unless Level 5 is recommended by the wallcovering manufacturer. Thoroughly dry surfaces at least 30 days prior to installation of vinyl wallcovering. Provide interior surfaces of new and existing gypsum wallboard with a wallcovering primer in accordance with the manufacturer's printed instructions. As required, use white primer when substrate color variations are visible through thin or light color wallcovering. Seal interior surfaces of exterior masonry walls to prevent moisture penetration, then prime with a wallcovering primer in accordance with the manufacturer's printed instructions. Provide masonry walls with flush joints. Test moisture content of plaster, concrete, and masonry with an electric moisture meter of a maximum five percent reading. Apply a thin coat of joint compound or cement plaster, as recommended by the wallcovering manufacturer, to the concrete and masonry walls as a substrate preparation. To promote adequate adhesion of wall lining over masonry walls, prime the walls as recommended by the wall lining manufacturer. Prime the surfaces of walls as required by the manufacturer's printed instructions to permit ultimate removal of wallcovering from the wall surfaces. Allow primer to completely dry before adhesive application.

3.3 INSTALLATION

3.3.1 Wallcovering

Install wallcovering in accordance with the manufacturer's printed installation instructions. Remove glue and adhesive spillage from wallcovering face and seams with a remover recommended by the manufacturer.

3.3.1.1 Textile Wallcovering

When textile wallcoverings are specified to comply with NFPA 265, NFPA 286, or ICC IBC (Section 803.5 Textile wall coverings) testing, install the wallcovering in accordance with the manufacturer's printed installation instructions for compliance with the testing using the same product mounting system, including adhesive. After the installation is complete, vacuum the fabric with a ceiling to floor motion.

3.3.1.2 Acoustical Wallcovering

When acoustical wallcoverings are specified to comply with NFPA 265, NFPA 286, or ICC IBC (Section 803.5 Textile wall coverings) testing, install the wallcovering in accordance with the manufacturer's printed installation instructions for compliance with the testing using the same product mounting system, including adhesive. After the installation is complete, vacuum the fabric with a ceiling to floor motion.

3.3.1.3 Presentation Dry Erase Wallcovering Placement

Install presentation dry erase wallcovering wall-to-wall and floor-to-ceiling and horizontally on the wall. Make the first seam at 610 mm (24 inch) above finished floor for rooms with 2440 mm (8 foot) ceilings and 760 mm (30 inch) above finished floor for rooms with 2740 mm (9 foot) ceilings. Do not make seams at writing height to provide a continual, seamless writing surface. Provide wallcovering with an oak frame. When frame and tray are required for presentation dry erase wallcovering, install them in accordance with manufacturer's installation instructions. Upon completion of presentation dry erase wallcovering installation, clean the wallcovering surface as recommended by the manufacturer prior to first use. Provide a mounting height of framed wallcovering as shown on the drawings. Wallcovering locations are as indicated on drawings

3.3.2 Wall Liner

Install wall liner over masonry walls that are to receive wallcovering. Install liner in accordance with the manufacturer's printed installation instructions. Install liner perpendicular to wallcovering to prevent overlapping of seams between liner and wallcovering.

3.3.3 Corner Guards and Wainscot Cap

Install corner guards and wainscot cap on all exposed corners with wallcovering and in accordance with the manufacturer's printed instructions. Run corner guards from top of base to ceiling in a continuous length.

3.4 CLEAN-UP

Upon completion of the work, clean wallcovering free of dirt, soiling, stain, or residual film. Remove and clean surplus materials, rubbish, and debris resulting from the wallcovering installation.

-- End of Section --

SECTION 09 83 13

ACOUSTICAL WALL TREATMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC 16	(2004; E 2008; E 2010) Colorfastness to Light

ASTM INTERNATIONAL (ASTM)

ASTM C423	(2009a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM D5034	(2009; R 2013) Breaking Strength and Elongation of Textile Fabrics (Grab Test)
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2012) International Building Code

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	Scientific Certification Systems (SCS)Indoor Advantage

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC	Leadership in Energy and Environmental Design(tm) New Construction Rating System

UL ENVIRONMENT (ULE)

ULE Greenguard	UL Greenguard Certification Program

1.2 SUSTAINABILITY REQUIREMENTS

Materials in this technical specification may contribute towards contract compliance with sustainability requirements.

1.2.1 LEED REQUIREMENTS

See Section 01 33 29 LEED DOCUMENTATION for project LEED NC local/regional materials, low-emitting materials, recycled content, certified wood and rapidly renewable materials requirements.

1.2.2 EPA Comprehensive Procurement Guidelines

MATERIALS for requirements associated with EPA designated products.

1.2.3 USDA Biobased

MATERIALS for requirements associated with USDA Biobased designated products.

1.2.4 Air Quality Certification

Product shall be third party certified in accordance with ULE Greenguard Gold, SCS Scientific Certification Systems Indoor Advantage Gold or equal. Certification shall be performed annually and shall be current.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G

SD-03 Product Data

Installation
Acoustical Wall Panels; G

SD-04 Samples

Acoustical Wall Panels; G

SD-07 Certificates

Acoustical Wall Panels

SD-11 Closeout Submittals

LEED Documentation

1.4 DELIVERY, STORAGE, AND HANDLING

Protect materials delivered and placed in storage from the weather, humidity and temperature variations, dirt, dust, or other contaminants.

1.5 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a one year period.

PART 2 PRODUCTS

2.1 FABRIC COVERED ACOUSTICAL WALL PANELS

Provide acoustical wall panels consisting of prefinished, factory assembled, seamless fabric covered, fiber glass or mineral fiber core system as described below manufactured to the dimensions and configurations shown on the approved detail drawings; submit drawings showing plan locations, elevations and details of method of anchorage, location of doors and other openings, base detail and shape and thickness of materials. Perimeter edges shall be non-reinforced, reinforced by either an aluminum frame or a formulated resin edge hardener. Acoustical wall panels installed in non-sprinklered areas shall comply with the requirements of ICC IBC, Standard 42-2. Comply with EPA requirements . Submit manufacturer's descriptive data and catalog cuts; fabric and vinyl swatches, minimum 450 mm (18 inch) wide by 600 mm (24 inch) long 5 samples of each color range specified; and certificates of compliance from an independent laboratory accredited by the National Laboratory Accreditation Program of the National Institute of Standards. A label or listing from the testing laboratory will be acceptable evidence of compliance. Wall panels shall conform to the following:

2.1.1 Panel Width

Widths shall be 600, 750, 1200, 1500 mm (24, 30, 48, 60 inch). End panels may vary in width as necessary to cover wall Panel width shall be as detailed.

2.1.2 Panel Height

Heights shall be 2400, 2700, 3000 mm (96, 108, 120 inch). Panels shall be field measured for custom fit to ceiling. Tolerance at floor to be as detailed. Panel height shall be as detailed.

2.1.3 Thickness

Panel thickness as required to meet the indicated NRC range.

2.1.4 Fabric Covering

Seamless non-woven, embossed texture, needle punched 100 percent polyester, minimum 0.034 kg/linear meter (11 ounces/linear yard). Tear strength a minimum 110 N (25 pound) machine direction and minimum 178 N (40 pound) cross-machine direction. Tensile strength a minimum 220 N (50 pound) machine direction and minimum 330 N (75 pound) cross-machine direction in accordance with ASTM D5034.plain woven 2-ply 100 percent polyester, minimum 0.47 kg/linear meter (15 ounces/linear yard). Tear strength a minimum 129 N (29 pound). Tensile strength 667 N (150 pound) minimum in accordance with ASTM D5034.perforated vinyl covering with fabric backing, minimum 0.62 kg/linear meter (20 ounces/linear yard) total weight. Stretch fabric covering free of wrinkles and then bond to the edges and back or bond directly to the panel face, edges, and back of panel a minimum distance standard with the manufacturer. Light fastness (fadeometer) approximately 40 hours in accordance with AATCC 16.

2.1.5 Fire Rating for the Complete Composite System

Class A, 200 or less smoke density and flame spread less than 25, when tested in accordance with ASTM E84.

2.1.6 Substrate

Fiber glass or mineral fiber

2.1.7 Noise Reduction Coefficient (NRC) Range

0.50-0.60 0.80-0.90 ASTM C423

2.1.8 Edge Detail

Half bevel Bevel Radius Square Mitered edge

2.1.9 Core Type

Standard acoustical High impact acoustical Acoustical/tackable core

2.1.10 MountingAcoustical panels shall be mounted by manufacturer's standard concealed spline mechanical fasteners magnetic fasteners hook and loop adhesive mounting.

2.2 COLOR

As indicated Selected from manufacturers standard colors. Color listed is not intended to limit the selection of equal colors from other manufacturers.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

Walls shall be clean, smooth, oil free and prepared in accordance with panel manufacturer's instructions. Do not begin installation until all wet work, such as, plastering, painting, and concrete are completely dry.

3.2 INSTALLATION

Panel installation shall be by personnel familiar with and normally engaged in installation of acoustical wall panels. Apply panels in accordance with the manufacturer's installation instructions. Submit manufacturer's installation instructions and recommended cleaning instructions.

3.3 CLEANING

Following installation, dirty or stained panel surfaces shall be cleaned in accordance with manufacturer's instructions and left free from defects. Panels that are damaged, discolored, or improperly installed shall be removed and new panels provided as directed.

-- End of Section --

SECTION 09 90 00

PAINTS AND COATINGS
05/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH 0100	(2001; Supplements 2002-2008) Documentation of the Threshold Limit Values and Biological Exposure Indices

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM D235	(2002; R 2012) Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
ASTM D2824	(2006; E 2012; R 2012) Aluminum-Pigmented Asphalt Roof Coatings, Non-Fibered, Asbestos Fibered, and Fibered without Asbestos
ASTM D4214	(2007) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D4263	(1983; R 2012) Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4444	(2008) Use and Calibration of Hand-Held Moisture Meters
ASTM D523	(2014) Standard Test Method for Specular Gloss
ASTM D6386	(2010) Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
ASTM F1869	(2011) Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

MASTER PAINTERS INSTITUTE (MPI)

MPI 1	(Oct 2009) Aluminum Paint
MPI 10	(Oct 2009) Exterior Latex, Flat, MPI Gloss Level 1
MPI 101	(Oct 2009) Epoxy Anti-Corrosive Metal Primer
MPI 107	(Oct 2009) Rust Inhibitive Primer (Water-Based)
MPI 108	(Oct 2009) High Build Epoxy Coating, Low Gloss
MPI 11	(Oct 2009) Exterior Latex, Semi-Gloss, MPI Gloss Level 5
MPI 113	(Oct 2009) Exterior Pigmented Elastomeric Coating (Water Based)
MPI 116	(Oct 2009) Epoxy Block Filler
MPI 119	(Oct 2009) Exterior Latex, Gloss
MPI 13	(Oct 2009) Exterior Solvent-Based Semi-Transparent Stain
MPI 134	(Oct 2009) Galvanized Primer (Waterbased)
MPI 138	(Oct 2009) Interior High Performance Latex, MPI Gloss Level 2
MPI 139	(Oct 2009) Interior High Performance Latex, MPI Gloss Level 3
MPI 140	(Oct 2009) Interior High Performance Latex, MPI Gloss Level 4
MPI 141	(Oct 2009) Interior High Performance Latex MPI Gloss Level 5
MPI 144	(Oct 2009) Institutional Low Odor / VOC Interior Latex, MPI Gloss Level 2
MPI 145	(Oct 2009) Institutional Low Odor / VOC Interior Latex, MPI Gloss Level 3
MPI 146	(Oct 2009) Institutional Low Odor/VOC Interior Latex, MPI Gloss Level 4
MPI 147	(Oct 2009) Institutional Low Odor / VOC Interior Latex, Semi-Gloss, MPI Gloss Level 5
MPI 151	(Oct 2009) Interior W.B. Light Industrial Coating, MPI Gloss Level 3

MPI 153	(Oct 2009) Interior W.B. Light Industrial Coating, Semi-Gloss, MPI Gloss Level 5
MPI 154	(Oct 2009) Interior W.B. Light Industrial Coating, Gloss, MPI Gloss Level 6
MPI 16	(Oct 2009) Exterior Latex-Based Solid Hide Stain
MPI 161	(Oct 2009) Exterior W.B. Light Industrial Coating, MPI Gloss Level 3
MPI 163	(Oct 2009) Exterior W.B. Light Industrial Coating, Semi-Gloss, MPI Gloss Level 5
MPI 164	(Oct 2009) Exterior W.B. Light Industrial Coating, Gloss, MPI Gloss Level 6
MPI 19	(Oct 2009) Inorganic Zinc Rich Primer
MPI 2	(Oct 2009) Aluminum Heat Resistant Enamel (up to 427 C and 800 F
MPI 21	(Oct 2009) Heat Resistant Enamel, Gloss (up to 205 degrees C and 400 degrees F), MPI Gloss Level 6
MPI 22	(Oct 2009) Aluminum Paint, High Heat (up to 590 degrees C and 1100 degrees F.
MPI 23	(Oct 2009) Surface Tolerant Metal Primer
MPI 26	(Oct 2009) Cementitious Galvanized Metal Primer
MPI 27	(Oct 2009) Exterior / Interior Alkyd Floor Enamel, Gloss
MPI 31	(Oct 2009) Polyurethane, Moisture Cured, Clear Gloss
MPI 39	(Oct 2009) Interior Latex-Based Wood Primer
MPI 4	(Oct 2009) Interior/Exterior Latex Block Filler
MPI 42	(Oct 2009) Latex Stucco and Masonry Textured Coating
MPI 44	(Oct 2009) Interior Latex, MPI Gloss Level 2
MPI 45	(Oct 2009) Interior Alkyd Primer Sealer
MPI 46	(Oct 2009) Interior Enamel Undercoat
MPI 47	(Oct 2009) Interior Alkyd, Semi-Gloss, MPI Gloss Level 5

MPI 48	(Oct 2009) Interior Alkyd, Gloss, MPI Gloss Level 6
MPI 49	(Oct 2009) Interior Alkyd, Flat, MPI Gloss Level 1
MPI 5	(Oct 2009) Exterior Alkyd Wood Primer
MPI 50	(Oct 2009) Interior Latex Primer Sealer
MPI 51	(Oct 2009) Interior Alkyd, Eggshell, MPI Gloss Level 2
MPI 52	(Oct 2009) Interior Latex, MPI Gloss Level 3
MPI 54	(Oct 2009) Interior Latex, Semi-Gloss, MPI Gloss Level 5
MPI 56	(Oct 2009) Interior Oil Modified Urethane Clear Gloss
MPI 57	(Oct 2009) Interior Oil Modified Urethane Clear Satin
MPI 59	(Oct 2009) Interior/Exterior Floor Enamel, Low Gloss
MPI 6	(Oct 2009) Exterior Latex Wood Primer
MPI 60	(Oct 2009) Interior/Exterior Latex Floor Paint, Low Gloss
MPI 68	(Oct 2009) Interior/Exterior Latex Floor Enamel, Gloss
MPI 7	(Oct 2009) Exterior Oil Wood Primer
MPI 71	(Oct 2009) Polyurethane, Moisture Cured, Clear, Flat
MPI 72	(Oct 2009) Polyurethane, Two Component, Pigmented, Gloss
MPI 77	(Oct 2009) Epoxy Gloss
MPI 79	(Oct 2009) Alkyd Anti-Corrosive Metal Primer
MPI 8	(Oct 2009) Exterior Alkyd, Flat, MPI Gloss Level I
MPI 9	(Oct 2009) Exterior Alkyd, Gloss, MPI Gloss Level 6
MPI 90	(Oct 2009) Interior Wood Stain, Semi-Transparent
MPI 94	(Oct 2009) Exterior Alkyd, Semi-Gloss, MPI

	Gloss Level 5
MPI 95	(Oct 2009) Quick Drying Primer for Aluminum

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007; E 2004) Brush-Off Blast Cleaning
SSPC PA 1	(2000; E 2004) Shop, Field, and Maintenance Painting of Steel
SSPC PA Guide 3	(1982; E 1995) A Guide to Safety in Paint Application
SSPC Paint 18	(1982; E 2004) Chlorinated Rubber Intermediate Coat Paint
SSPC SP 1	(1982; E 2004) Solvent Cleaning
SSPC SP 10/NACE No. 2	(2007) Near-White Blast Cleaning
SSPC SP 12/NACE No.5	(2002) Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating
SSPC SP 2	(1982; E 2000; E 2004) Hand Tool Cleaning
SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning
SSPC VIS 1	(2002; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC VIS 3	(2004) Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning
SSPC VIS 4/NACE VIS 7	(1998; E 2000; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-680	(2010; Rev C) Degreasing Solvent
MIL-STD-101	(1970; Rev B) Color Code for Pipelines & for Compressed Gas Cylinders

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA Method 24	(2000) Determination of Volatile Matter Content, Water Content, Density, Volume

	Solids, and Weight Solids of Surface Coatings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-313	(Rev D; Notice 1) Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1000	Air Contaminants

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

The current MPI, "Approved Product List" which lists paint by brand, label, product name and product code as of the date of contract award, will be used to determine compliance with the submittal requirements of this specification. The Contractor may choose to use a subsequent MPI "Approved Product List", however, only one list may be used for the entire contract and each coating system is to be from a single manufacturer. All coats on a particular substrate must be from a single manufacturer. No variation from the MPI Approved Products List is acceptable.

Samples of specified materials may be taken and tested for compliance with specification requirements.

SD-03 Product Data

Coating
Manufacturer's Technical Data Sheets

SD-07 Certificates

Applicator's qualifications
Qualification Testing laboratory for coatings

SD-08 Manufacturer's Instructions

Application instructions
Mixing
Manufacturer's Material Safety Data Sheets

SD-10 Operation and Maintenance Data

Cleaning and Maintenance Instructions

1.3 APPLICATOR'S QUALIFICATIONS

1.3.1 Contractor Qualification

Submit the name, address, telephone number, FAX number, and e-mail address of the contractor that will be performing all surface preparation and coating application. Submit evidence that key personnel have successfully performed surface preparation and application of coatings on a minimum of three similar projects within the past three years. List information by individual and include the following:

a. Name of individual and proposed position for this work.

b. Information about each previous assignment including:

Position or responsibility

Employer (if other than the Contractor)

Name of facility owner

Mailing address and telephone number of facility owner

Name of individual in facility owner's organization who can be contacted as a reference

Location, size and description of structure

Dates work was carried out

Description of work carried out on structure

1.4 QUALITY ASSURANCE

1.4.1 Field Samples and Tests

The Contracting Officer may choose up to two coatings that have been delivered to the site to be tested at no cost to the Government. Take samples of each chosen product as specified in the paragraph "Sampling Procedures." Test each chosen product as specified in the paragraph "Testing Procedure." Products which do not conform, shall be removed from the job site and replaced with new products that conform to the referenced specification. Testing of replacement products that failed initial testing shall be at no cost to the Government.

1.4.1.1 Sampling Procedure

The Contracting Officer will select paint at random from the products that have been delivered to the job site for sample testing. The Contractor shall provide one liter (one quart) samples of the selected paint materials. The samples shall be taken in the presence of the Contracting Officer, and labeled, identifying each sample. Provide labels in accordance with the paragraph "Packaging, Labeling, and Storage" of this specification.

1.4.1.2 Testing Procedure

Provide Batch Quality Conformance Testing for specified products, as defined by and performed by MPI. As an alternative to Batch Quality Conformance Testing, the Contractor may provide Qualification Testing for specified products above to the appropriate MPI product specification, using the third-party laboratory approved under the paragraph

"Qualification Testing" laboratory for coatings. The qualification testing lab report shall include the backup data and summary of the test results. The summary shall list all of the reference specification requirements and the result of each test. The summary shall clearly indicate whether the tested paint meets each test requirement. Note that Qualification Testing may take 4 to 6 weeks to perform, due to the extent of testing required.

Submit name, address, telephone number, and e-mail address of the independent third party laboratory selected to perform testing of coating samples for compliance with specification requirements. Submit documentation that laboratory is regularly engaged in testing of paint samples for conformance with specifications, and that employees performing testing are qualified. If the Contractor chooses MPI to perform the Batch Quality Conformance testing, the above submittal information is not required, only a letter is required from the Contractor stating that MPI will perform the testing.

1.5 REGULATORY REQUIREMENTS

1.5.1 Environmental Protection

In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local Air Pollution Control District and regional jurisdiction. Notify Contracting Officer of any paint specified herein which fails to conform.

1.5.2 Lead Content

Do not use coatings having a lead content over 0.06 percent by weight of nonvolatile content.

1.5.3 Chromate Content

Do not use coatings containing zinc-chromate or strontium-chromate.

1.5.4 Asbestos Content

Materials shall not contain asbestos.

1.5.5 Mercury Content

Materials shall not contain mercury or mercury compounds.

1.5.6 Silica

Abrasive blast media shall not contain free crystalline silica.

1.5.7 Human Carcinogens

Materials shall not contain ACGIH 0100 confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.6 PACKAGING, LABELING, AND STORAGE

Paints shall be in sealed containers that legibly show the contract specification number, designation name, formula or specification number, batch number, color, quantity, date of manufacture, manufacturer's formulation number, manufacturer's directions including any warnings and special precautions, and name and address of manufacturer. Pigmented paints shall be furnished in containers not larger than 20 liters (5 gallons). Paints and thinners shall be stored in accordance with the manufacturer's written directions, and as a minimum, stored off the ground, under cover, with sufficient ventilation to prevent the buildup of flammable vapors, and at temperatures between 4 to 35 degrees C (40 to 95 degrees F).

1.7 SAFETY AND HEALTH

Apply coating materials using safety methods and equipment in accordance with the following:

Work shall comply with applicable Federal, State, and local laws and regulations, and with the ACCIDENT PREVENTION PLAN, including the Activity Hazard Analysis as specified in Section 01 35 26 GOVERNMENT SAFETY REQUIREMENTS and in Appendix A of EM 385-1-1. The Activity Hazard Analysis shall include analyses of the potential impact of painting operations on painting personnel and on others involved in and adjacent to the work zone.

1.7.1 Safety Methods Used During Coating Application

Comply with the requirements of SSPC PA Guide 3.

1.7.2 Toxic Materials

To protect personnel from overexposure to toxic materials, conform to the most stringent guidance of:

a. The applicable manufacturer's Material Safety Data Sheets (MSDS) or local regulation. Submit MSDS for coatings, solvents, and other potentially hazardous materials, as defined in FED-STD-313.

b. 29 CFR 1910.1000.

c. ACGIH 0100, threshold limit values.

1.8 ENVIRONMENTAL CONDITIONS

Comply, at minimum, with manufacturer recommendations for space ventilation during and after installation.

1.8.1 Coatings

Do not apply coating when air or substrate conditions are:

a. Less than 3 degrees C (5 degrees F) above dew point;

b. Below 10 degrees C (50 degrees F) or over 35 degrees C (95 degrees F), unless specifically pre-approved by the Contracting Officer and the product manufacturer. Under no circumstances shall application conditions exceed manufacturer recommendations.

1.9 LOCATION AND SURFACE TYPE TO BE PAINTED

1.9.1 Painting Included

Where a space or surface is indicated to be painted, include the following unless indicated otherwise.

a. Surfaces behind portable objects and surface mounted articles readily detachable by removal of fasteners, such as screws and bolts.

b. New factory finished surfaces that require identification or color coding and factory finished surfaces that are damaged during performance of the work.

c. Existing coated surfaces that are damaged during performance of the work.

1.9.1.1 Exterior Painting

Includes new surfaces and existing uncoated surfaces of the building(s) and appurtenances. Also included are existing coated surfaces made bare by cleaning operations.

1.9.1.2 Interior Painting

Includes new surfaces and existing uncoated surfaces of the building(s) and appurtenances as indicated and existing coated surfaces made bare by cleaning operations. Where a space or surface is indicated to be painted, include the following items, unless indicated otherwise.

a. Exposed columns, girders, beams, joists, and metal deck; and

b. Other contiguous surfaces.

1.9.2 Painting Excluded

Do not paint the following unless indicated otherwise.

a. Surfaces concealed and made inaccessible by panelboards, fixed ductwork, machinery, and equipment fixed in place.

b. Surfaces in concealed spaces. Concealed spaces are defined as enclosed spaces above suspended ceilings, furred spaces, attic spaces, crawl spaces, elevator shafts and chases.

c. Steel to be embedded in concrete.

d. Copper, stainless steel, aluminum, brass, and lead except existing coated surfaces.

e. Hardware, fittings, and other factory finished items.

1.9.3 Mechanical and Electrical Painting

Includes field coating of interior and exterior new and existing surfaces.

a. Where a space or surface is indicated to be painted, include the following items unless indicated otherwise.

(1) Exposed piping, conduit, and ductwork;

(2) Supports, hangers, air grilles, and registers;

(3) Miscellaneous metalwork and insulation coverings.

b. Do not paint the following, unless indicated otherwise:

(1) New zinc-coated, aluminum, and copper surfaces under insulation

(2) New aluminum jacket on piping

(3) New interior ferrous piping under insulation.

1.9.3.1 Fire Extinguishing Sprinkler Systems

Clean, pretreat, prime, and paint new fire extinguishing sprinkler systems including valves, piping, conduit, hangers, supports, miscellaneous metalwork, and accessories. Apply coatings to clean, dry surfaces, using clean brushes. Clean the surfaces to remove dust, dirt, rust, and loose mill scale. Immediately after cleaning, provide the metal surfaces with one coat primer per schedules. Shield sprinkler heads with protective covering while painting is in progress. Upon completion of painting, remove protective covering from sprinkler heads. Remove sprinkler heads which have been painted and replace with new sprinkler heads. Provide primed surfaces with the following:

a. Piping in Unfinished Areas: Provide primed surfaces with one coat of red alkyd gloss enamel applied to a minimum dry film thickness of 0.025 mm (1.0 mil) in attic spaces, spaces above suspended ceilings, crawl spaces, pipe chases, mechanical equipment room, and spaces where walls or ceiling are not painted or not constructed of a prefinished material.

b. Piping in Finished Areas: Provide primed surfaces with two coats of paint to match adjacent surfaces, except provide valves and operating accessories with one coat of red alkyd gloss enamel applied to a minimum dry film thickness of 0.025 mm (1.0 mil). Provide piping with 50 mm (2 inch) wide red enamel bands or self-adhering red plastic bands spaced at maximum of 6 meters (20 foot) intervals throughout the piping systems.

1.9.4 MISCELLANEOUS PAINTING

Lettering Building and Room Number(s)

Lettering shall be provided as scheduled on the drawings, shall be block type, and shall be black enamel . Samples shall be approved before application.

1.9.5 Definitions and Abbreviations

1.9.5.1 Qualification Testing

Qualification testing is the performance of all test requirements listed in the product specification. This testing is accomplished by MPI to qualify each product for the MPI Approved Product List, and may also be accomplished by Contractor's third party testing lab if an alternative to Batch Quality Conformance Testing by MPI is desired.

1.9.5.2 Batch Quality Conformance Testing

Batch quality conformance testing determines that the product provided is the same as the product qualified to the appropriate product specification. This testing shall only be accomplished by MPI testing lab.

1.9.5.3 Coating

A film or thin layer applied to a base material called a substrate. A coating may be a metal, alloy, paint, or solid/liquid suspensions on various substrates (metals, plastics, wood, paper, leather, cloth, etc.). They may be applied by electrolysis, vapor deposition, vacuum, or mechanical means such as brushing, spraying, calendaring, and roller coating. A coating may be applied for aesthetic or protective purposes or both. The term "coating" as used herein includes emulsions, enamels, stains, varnishes, sealers, epoxies, and other coatings, whether used as primer, intermediate, or finish coat. The terms paint and coating are used interchangeably.

1.9.5.4 DFT or dft

Dry film thickness, the film thickness of the fully cured, dry paint or coating.

1.9.5.5 DSD

Degree of Surface Degradation, the MPI system of defining degree of surface degradation. Five (5) levels are generically defined under the Assessment sections in the MPI Maintenance Repainting Manual.

1.9.5.6 EPP

Environmentally Preferred Products, a standard for determining environmental preferability in support of Executive Order 13101.

1.9.5.7 EXT

MPI short term designation for an exterior coating system.

1.9.5.8 INT

MPI short term designation for an interior coating system.

1.9.5.9 micron / microns

The metric measurement for 0.001 mm or one/one-thousandth of a millimeter.

1.9.5.10 mil / mils

The English measurement for 0.001 in or one/one-thousandth of an inch, equal to 25.4 microns or 0.0254 mm.

1.9.5.11 mm

The metric measurement for millimeter, 0.001 meter or one/one-thousandth of a meter.

1.9.5.12 MPI Gloss Levels

MPI system of defining gloss. Seven (7) gloss levels (G1 to G7) are generically defined under the Evaluation sections of the MPI Manuals. Traditionally, Flat refers to G1/G2, Eggshell refers to G3, Semigloss refers to G5, and Gloss refers to G6.

Gloss levels are defined by MPI as follows:

Gloss Level	Description	Units at 16 degrees C (60 degrees F)	Units at 29 degrees C (85 degrees F)
G1	Matte or Flat	0 to 5	10 max
G2	Velvet	0 to 10	10 to 35
G3	Eggshell	10 to 25	10 to 35
G4	Satin	20 to 35	35 min
G5	Semi-Gloss	35 to 70	
G6	Gloss	70 to 85	
G7	High Gloss		

Gloss is tested in accordance with ASTM D523. Historically, the Government has used Flat (G1 / G2), Eggshell (G3), Semi-Gloss (G5), and Gloss (G6).

1.9.5.13 MPI System Number

The MPI coating system number in each Division found in either the MPI Architectural Painting Specification Manual or the Maintenance Repainting Manual and defined as an exterior (EXT/REX) or interior system (INT/RIN). The Division number follows the CSI Master Format.

1.9.5.14 Paint

See Coating definition.

1.9.5.15 REX

MPI short term designation for an exterior coating system used in repainting projects or over existing coating systems.

1.9.5.16 RIN

MPI short term designation for an interior coating system used in repainting projects or over existing coating systems.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the coating specifications and standards referenced in PART 3. Submit manufacturer's technical data sheets for specified coatings and solvents. Comply with applicable regulations regarding toxic and hazardous materials.

2.2 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PROTECTION OF AREAS AND SPACES NOT TO BE PAINTED

Prior to surface preparation and coating applications, remove, mask, or otherwise protect, hardware, hardware accessories, machined surfaces, radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated. Following completion of painting, workmen skilled in the trades involved shall reinstall removed items. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.2 SURFACE PREPARATION

Remove dirt, splinters, loose particles, grease, oil, disintegrated coatings, and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments. Oil and grease shall be removed prior to mechanical cleaning. Cleaning shall be programmed so that dust and other contaminants will not fall on wet, newly painted surfaces. Exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, shall be spot-primed with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas.

3.2.1 Additional Requirements for Preparation of Surfaces With Existing Coatings

Before application of coatings, perform the following on surfaces covered by soundly-adhered coatings, defined as those which cannot be removed with a putty knife:

a. Test existing finishes for lead before sanding, scraping, or removing. If lead is present, refer to paragraph Toxic Materials.

b. Wipe previously painted surfaces to receive solvent-based coatings, except stucco and similarly rough surfaces clean with a clean, dry cloth saturated with mineral spirits, ASTM D235. Allow surface to dry. Wiping shall immediately precede the application of the first coat of any coating, unless specified otherwise.

c. Sand existing glossy surfaces to be painted to reduce gloss. Brush, and wipe clean with a damp cloth to remove dust.

d. The requirements specified are minimum. Comply also with the application instructions of the paint manufacturer.

e. Previously painted surfaces specified to be repainted and damaged during construction shall be thoroughly cleaned of all grease, dirt, dust or other foreign matter.

f. Blistering, cracking, flaking and peeling or other deteriorated coatings shall be removed.

g. Chalk shall be removed so that when tested in accordance with ASTM D4214, the chalk resistance rating is no less than 8.

h. Slick surfaces shall be roughened. Damaged areas such as, but not limited to, nail holes, cracks, chips, and spalls shall be repaired with suitable material to match adjacent undamaged areas.

i. Edges of chipped paint shall be feather edged and sanded smooth.

j. Rusty metal surfaces shall be cleaned as per SSPC requirements. Solvent, mechanical, or chemical cleaning methods shall be used to provide surfaces suitable for painting.

k. New, proposed coatings shall be compatible with existing coatings.

3.2.2 Existing Coated Surfaces with Minor Defects

Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings.

3.2.3 Removal of Existing Coatings

Remove existing coatings from the following surfaces:

a. Surfaces containing large areas of minor defects;

b. Surfaces containing more than 20 percent peeling area; and

c. Surfaces designated by the Contracting Officer, such as surfaces where rust shows through existing coatings.

3.2.4 Substrate Repair

a. Repair substrate surface damaged during coating removal;

b. Sand edges of adjacent soundly-adhered existing coatings so they are tapered as smooth as practical to areas involved with coating removal; and

c. Clean and prime the substrate as specified.

3.3 PREPARATION OF METAL SURFACES

3.3.1 Existing and New Ferrous Surfaces

a. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Solvent clean or detergent wash in accordance with SSPC SP 1 to remove oil and grease. Where shop coat is missing or damaged, clean according to SSPC SP 2, SSPC SP 3, SSPC SP 6/NACE No.3, or SSPC SP 10/NACE No. 2. Brush-off blast remaining surface in accordance with SSPC 7/NACE No.4; Water jetting to SSPC SP 12/NACE No.5 WJ-4 may be used to remove loose coating and other loose materials. Use inhibitor as recommended by coating manufacturer to prevent premature rusting. Shop-coated ferrous surfaces shall be protected from corrosion by treating and touching up corroded areas immediately upon detection.

b. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with SSPC SP 6/NACE No.3/SSPC SP 12/NACE No.5 WJ-3 or SSPC SP 10/NACE No. 2/ SSPC SP 12/NACE No.5 WJ-2.

c. Metal Floor Surfaces to Receive Nonslip Coating: Clean in accordance with SSPC SP 10/NACE No. 2 or SSPC SP 12/NACE No.5 WJ-2.

3.3.2 Final Ferrous Surface Condition:

For tool cleaned surfaces, the requirements are stated in SSPC SP 2 and SSPC SP 3. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 3.

For abrasive blast cleaned surfaces, the requirements are stated in SSPC 7/NACE No.4, SSPC SP 6/NACE No.3, and SSPC SP 10/NACE No. 2. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 1.

For waterjet cleaned surfaces, the requirements are stated in SSPC SP 12/NACE No.5. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 4/NACE VIS 7.

3.3.3 Galvanized Surfaces

a. New or Existing Galvanized Surfaces With Only Dirt and Zinc Oxidation Products: Clean with solvent, steam, or non-alkaline detergent solution in accordance with SSPC SP 1. If the galvanized metal has been passivated or stabilized, the coating shall be completely removed by brush-off abrasive blast. New galvanized steel to be coated shall not be "passivated" or "stabilized" If the absence of hexavalent stain inhibitors is not documented, test as described in ASTM D6386, Appendix X2, and remove by one of the methods described therein.

b. Galvanized with Slight Coating Deterioration or with Little or No Rusting: Water jetting to SSPC SP 12/NACE No.5 WJ3 to remove loose coating from surfaces with less than 20 percent coating deterioration and no blistering, peeling, or cracking. Use inhibitor as recommended by the coating manufacturer to prevent rusting.

c. Galvanized With Severe Deteriorated Coating or Severe Rusting: Water jet to SSPC SP 12/NACE No.5 WJ3 degree of cleanliness. Spot abrasive blast rusted areas as described for steel in SSPC SP 6/NACE No.3, and waterjet to SSPC SP 12/NACE No.5, WJ3 to remove existing coating.

3.3.4 Non-Ferrous Metallic Surfaces

Aluminum and aluminum-alloy, lead, copper, and other nonferrous metal surfaces.

Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

3.3.5 Terne-Coated Metal Surfaces

Solvent clean surfaces with mineral spirits, ASTM D235. Wipe dry with clean, dry cloths.

3.3.6 Existing Surfaces with a Bituminous or Mastic-Type Coating

Remove chalk, mildew, and other loose material by washing with a solution of 0.20 liter (1/2 cup) trisodium phosphate, 0.1 liter (1/4 cup) household detergent, 1.6 liters (one quart) 5 percent sodium hypochlorite solution and 4.8 liters (3 quarts) of warm water.

3.4 PREPARATION OF CONCRETE AND CEMENTITIOUS SURFACE

3.4.1 Concrete and Masonry

a. Curing: Concrete, stucco and masonry surfaces shall be allowed to cure at least 30 days before painting, except concrete slab on grade, which shall be allowed to cure 90 days before painting.

b. Surface Cleaning: Remove the following deleterious substances.

   (1) Dirt, Chalking, Grease, and Oil: Wash new and existing uncoated surfaces with a solution composed of 0.2 liter (1/2 cup) trisodium phosphate, 0.1 liter (1/4 cup)household detergent, and 6.4 liters (4 quarts) of warm water. Then rinse thoroughly with fresh water. Wash existing coated surfaces with a suitable detergent and rinse thoroughly. For large areas, water blasting may be used.

   (2) Fungus and Mold: Wash new , existing coated, and existing uncoated surfaces with a solution composed of 0.2 liter (1/2 cup) trisodium phosphate, 0.1 liter (1/4 cup) household detergent, 1.6 liters (1 quart) 5 percent sodium hypochlorite solution and 4.8 liters (3 quarts) of warm water. Rinse thoroughly with fresh water.

   (3) Paint and Loose Particles: Remove by wire brushing.

   (4) Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 0.4 square meter (4 square feet) of surface, per workman, at one time.

   (5) Removal of Existing Coatings: For surfaces to receive textured coating MPI 42, remove existing coatings including soundly adhered coatings if recommended by textured coating manufacturer.

c. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

d. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not to surfaces with droplets of water. Do not apply epoxies to damp vertical surfaces as determined by ASTM D4263 or horizontal surfaces that exceed 3 lbs of moisture per 1000 square feet in 24 hours as determined by ASTM F1869. In all cases follow manufacturers recommendations. Allow surfaces to cure a minimum of 30 days before painting.

3.4.2 Gypsum Board, Plaster, and Stucco

a. Surface Cleaning: Plaster and stucco shall be clean and free from loose matter; gypsum board shall be dry. Remove loose dirt and dust by brushing with a soft brush, rubbing with a dry cloth, or vacuum-cleaning prior to application of the first coat material. A damp cloth or sponge may be used if paint will be water-based.

b. Repair of Minor Defects: Prior to painting, repair joints, cracks, holes, surface irregularities, and other minor defects with patching plaster or spackling compound and sand smooth.

c. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not surfaces with droplets of water. Do not apply epoxies to damp surfaces as determined by ASTM D4263. New plaster to be coated shall have a maximum moisture content of 8 percent, when measured in accordance with ASTM D4444, Method A, unless otherwise authorized. In addition to moisture content requirements, allow new plaster to age a minimum of 30 days before preparation for painting.

3.4.3 Existing Asbestos Cement Surfaces

Remove oily stains by solvent cleaning with mineral spirits, MIL-PRF-680 or ASTM D235. Remove loose dirt, dust, and other deleterious substances by brushing with a soft brush or rubbing with a dry cloth prior to application of the first coat material. Do not wire brush or clean using other abrasive methods. Surfaces shall be dry and clean prior to application of the coating.

3.5 PREPARATION OF WOOD AND PLYWOOD SURFACES

3.5.1 New , Existing Uncoated, and Existing Coated Plywood and Wood Surfaces, Except Floors:

a. Wood surfaces shall be cleaned of foreign matter.

   Surface Cleaning: Surfaces shall be free from dust and other deleterious substances and in a condition approved by the Contracting Officer prior to receiving paint or other finish. Do not use water to clean uncoated wood. Scrape to remove loose coatings. Lightly sand to roughen the entire area of previously enamel-coated wood surfaces.

b. Removal of Fungus and Mold: Wash existing coated surfaces with a solution composed of 0.2 liter (3 ounces) trisodium phosphate, 0.1 liter (1 ounce) household detergent, 1.6 liters (1 quart) 5 percent sodium hypochlorite solution and 4.8 liters (3 quarts) of warm water. Rinse thoroughly with fresh water.

c. Moisture content of the wood shall not exceed 12 percent as measured by a moisture meter in accordance with ASTM D4444, Method A, unless otherwise authorized.

d. Wood surfaces adjacent to surfaces to receive water-thinned paints shall be primed and/or touched up before applying water-thinned paints.

e. Cracks and Nail heads: Set and putty stop nail heads and putty cracks after the prime coat has dried.

f. Cosmetic Repair of Minor Defects:

(1) Knots and Resinous Wood and Fire, Smoke, Water, and Color Marker Stained Existing Coated Surface: Prior to application of coating, cover knots and stains with two or more coats of 1.3-kg-cut (3-pound-cut) shellac varnish, plasticized with 0.14 liters (5 ounces) of castor oil per liter (gallon). Scrape away existing coatings from knotty areas, and sand before treating. Prime before applying any putty over shellacked area.

(2) Open Joints and Other Openings: Fill with whiting putty, linseed oil putty. Sand smooth after putty has dried.

(3) Checking: Where checking of the wood is present, sand the surface, wipe and apply a coat of pigmented orange shellac. Allow to dry before paint is applied.

g. Prime Coat For New Exterior Surfaces: Prime coat wood doors, windows, frames, and trim before wood becomes dirty, warped, or weathered.

3.5.2 Wood Floor Surfaces, Natural Finish

a. Initial Surface Cleaning: As specified in paragraph entitled "Surface Preparation."

b. Existing Loose Boards and Shoe Molding: Before sanding, re-nail loose boards. Countersink nails and fill with an approved wood filler. Remove shoe molding before sanding and reinstall after completing other work. At Contractor's option, new shoe molding may be provided in lieu of reinstalling old. New wood molding shall be same size, wood species, and finish as the existing.

c. Sanding and Scraping: Sanding of wood floors is specified in Section 09 64 29 WOOD STRIP FLOORING. Floors of oak or similar open-grain wood shall be filled with wood filler recommended by the finish manufacturer and the excess filler removed.

d. Final Cleaning: After sanding, sweep and vacuum floors clean. Do not walk on floors thereafter until specified sealer has been applied and is dry.

3.5.3 Interior Wood Surfaces, Stain Finish

Interior wood surfaces to receive stain shall be sanded. Oak and other open-grain wood to receive stain shall be given a coat of wood filler not less than 8 hours before the application of stain; excess filler shall be removed and the surface sanded smooth.

3.5.4 Water Blasting of Existing Coated Wood Surfaces:

a. Sample Panel: Prior to the initial surface cleaning, water blast a representative surface designated by the Contracting Officer. Final surface condition of remaining work shall be similar to sample panel approved by the Contracting Officer.

b. Initial Surface Cleaning: Water blasting shall consist of washing surfaces to receive paint with a high pressure spray, to remove loose paint, dirt, and other foreign or deleterious materials. The working pressure shall be between 2.8 and 4.8 MPa (400 and 700 pounds per square inch gage (psig)) at a nozzle operating rate of a minimum 75 liters per minute (l/min) (20 gallons per minute). Do not flood vents or damage windows and floors. If the pressure specified will cause damage to existing wood, advise the Contracting Officer and obtain permission to vary the pressure. Direct the wash nozzle at the surface at an angle of approximately 75 degrees with the surface and at a distance not greater than 1500 mm (5 feet) to apply water pressure required to remove loose paint, dirt, chalking, and other foreign matter.

c. Final Surface Cleaning: After allowing the surfaces to dry for a minimum of 24 hours, remove remaining dirt, splinters, loose particles, disintegrated and loose paint, grease, oil, and other foreign matter from the surface.

3.6 APPLICATION

3.6.1 Coating Application

Painting practices shall comply with applicable federal, state and local laws enacted to insure compliance with Federal Clean Air Standards. Apply coating materials in accordance with SSPC PA 1. SSPC PA 1 methods are applicable to all substrates, except as modified herein.

Submit detailed application instructions, minimum and maximum application temperature and humidity, pot life, and curing and drying times between coats.

At the time of application, paint shall show no signs of deterioration. Uniform suspension of pigments shall be maintained during application.

Unless otherwise specified or recommended by the paint manufacturer, paint may be applied by brush, roller, or spray. Use trigger operated spray nozzles for water hoses. Rollers for applying paints and enamels shall be of a type designed for the coating to be applied and the surface to be coated. Wear protective clothing and respirators when applying oil-based paints or using spray equipment with any paints.

Paints, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch.

Thoroughly work coating materials into joints, crevices, and open spaces. Special attention shall be given to insure that all edges, corners, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces.

Each coat of paint shall be applied so dry film shall be of uniform thickness and free from runs, drops, ridges, waves, pinholes or other voids, laps, brush marks, and variations in color, texture, and finish. Hiding shall be complete.

Touch up damaged coatings before applying subsequent coats. Interior areas shall be broom clean and dust free before and during the application of coating material.

Where indicated, apply paint to new fire extinguishing sprinkler systems including valves, piping, conduit, hangers, supports, miscellaneous metal work, and accessories. Shield sprinkler heads with protective coverings while painting is in progress. Remove sprinkler heads which have been painted and replace with new sprinkler heads. For piping in unfinished spaces, provide primed surfaces with one coat of red alkyd gloss enamel to a minimum dry film thickness of 0.025 mm (1.0 mil). Unfinished spaces include attic spaces, spaces above suspended ceilings, crawl spaces, pipe chases, mechanical equipment room, and space where walls or ceiling are not painted or not constructed of a prefinished material. For piping in finished areas, provide prime surfaces with two coats of paint to match adjacent surfaces, except provide valves and operating accessories with one coat of red alkyd gloss enamel. Upon completion of painting, remove protective covering from sprinkler heads.

a. Drying Time: Allow time between coats, as recommended by the coating manufacturer, to permit thorough drying, but not to present topcoat adhesion problems. Provide each coat in specified condition to receive next coat.

b. Primers, and Intermediate Coats: Do not allow primers or intermediate coats to dry more than 30 days, or longer than recommended by manufacturer, before applying subsequent coats. Follow manufacturer's recommendations for surface preparation if primers or intermediate coats are allowed to dry longer than recommended by manufacturers of subsequent coatings. Each coat shall cover surface of preceding coat or surface completely, and there shall be a visually perceptible difference in shades of successive coats.

c. Finished Surfaces: Provide finished surfaces free from runs, drops, ridges, waves, laps, brush marks, and variations in colors.

d. Thermosetting Paints: Topcoats over thermosetting paints (epoxies and urethanes) should be applied within the overcoating window recommended by the manufacturer.

e. Floors: For nonslip surfacing on level floors, as the intermediate coat is applied, cover wet surface completely with almandite garnet, Grit No. 36, with maximum passing U.S. Standard Sieve No. 40 less than 0.5 percent. When the coating is dry, use a soft bristle broom to sweep up excess grit, which may be reused, and vacuum up remaining residue before application of the topcoat. For nonslip surfacing on ramps, provide MPI 77 with non-skid additive, applied by roller in accordance with manufacturer's instructions.

3.6.2 Mixing and Thinning of Paints

Reduce paints to proper consistency by adding fresh paint, except when thinning is mandatory to suit surface, temperature, weather conditions, application methods, or for the type of paint being used. Obtain written permission from the Contracting Officer to use thinners. The written permission shall include quantities and types of thinners to use. Submit detailed mixing instructions, minimum and maximum application temperature and humidity, pot life, and curing and drying times between coats.

When thinning is allowed, paints shall be thinned immediately prior to application with not more than 0.125 L (1 pint) of suitable thinner per liter (gallon) . The use of thinner shall not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Thinning shall not cause the paint to exceed limits on volatile organic compounds. Paints of different manufacturers shall not be mixed.

3.6.3 Two-Component Systems

Two-component systems shall be mixed in accordance with manufacturer's instructions. Any thinning of the first coat to ensure proper penetration and sealing shall be as recommended by the manufacturer for each type of substrate.

3.6.4 Coating Systems

a. Systems by Substrates: Apply coatings that conform to the respective specifications listed in the following Tables:

Table

Division 3.	Exterior Concrete Paint Table
Division 4.	Exterior Concrete Masonry Units Paint Table
Division 5.	Exterior Metal, Ferrous and Non-Ferrous Paint Table
Division 6.	Exterior Wood; Dressed Lumber, Paneling, Decking, Shingles Paint Table
Division 9:	Exterior Stucco Paint Table
Division 10.	Exterior Cloth Coverings and Bituminous Coated Surfaces Paint Table
Division 3.	Interior Concrete Paint Table
Division 4.	Interior Concrete Masonry Units Paint Table
Division 5.	Interior Metal, Ferrous and Non-Ferrous Paint Table
Division 6.	Interior Wood Paint Table
Division 9:	Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

b. Minimum Dry Film Thickness (DFT): Apply paints, primers, varnishes, enamels, undercoats, and other coatings to a minimum dry film thickness of 0.038 mm (1.5 mil) each coat unless specified otherwise in the Tables. Coating thickness where specified, refers to the minimum dry film thickness.

c. Coatings for Surfaces Not Specified Otherwise: Coat surfaces which have not been specified, the same as surfaces having similar conditions of exposure.

d. Existing Surfaces Damaged During Performance of the Work, Including New Patches In Existing Surfaces: Coat surfaces with the following:

(1) One coat of primer.

(2) One coat of undercoat or intermediate coat.

(3) One topcoat to match adjacent surfaces.

e. Existing Coated Surfaces To Be Painted: Apply coatings conforming to the respective specifications listed in the Tables herein, except that pretreatments, sealers and fillers need not be provided on surfaces where existing coatings are soundly adhered and in good condition. Do not omit undercoats or primers.

3.7 COATING SYSTEMS FOR METAL

Apply coatings of Tables in Division 5 for Exterior and Interior.

a. Apply specified ferrous metal primer on the same day that surface is cleaned, to surfaces that meet all specified surface preparation requirements at time of application.

b. Inaccessible Surfaces: Prior to erection, use one coat of specified primer on metal surfaces that will be inaccessible after erection.

c. Shop-primed Surfaces: Touch up exposed substrates and damaged coatings to protect from rusting prior to applying field primer.

d. Surface Previously Coated with Epoxy or Urethane: Apply MPI 101, 0.038 mm (1.5 mils) DFT immediately prior to application of epoxy or urethane coatings.

e. Pipes and Tubing: The semitransparent film applied to some pipes and tubing at the mill is not to be considered a shop coat, but shall be overcoated with the specified ferrous-metal primer prior to application of finish coats.

f. Exposed Nails, Screws, Fasteners, and Miscellaneous Ferrous Surfaces. On surfaces to be coated with water thinned coatings, spot prime exposed nails and other ferrous metal with latex primer MPI 107.

3.8 COATING SYSTEMS FOR CONCRETE AND CEMENTITIOUS SUBSTRATES

Apply coatings of Tables in Division 3, 4 and 9 for Exterior and Interior.

3.9 COATING SYSTEMS FOR WOOD AND PLYWOOD

a. Apply coatings of Tables in Division 6 for Exterior and Interior.

b. Prior to erection, apply two coats of specified primer to treat and prime wood and plywood surfaces which will be inaccessible after erection.

c. Apply stains in accordance with manufacturer's printed instructions.

3.10 PIPING IDENTIFICATION

Piping Identification, Including Surfaces In Concealed Spaces: Provide in accordance with MIL-STD-101 and ASME A13.1. Place stenciling in clearly visible locations. On piping not covered by MIL-STD-101 and ASME A13.1, stencil approved names or code letters, in letters a minimum of 13 mm (1/2 inch) high for piping and a minimum of 50 mm (2 inches) high elsewhere. Stencil arrow-shaped markings on piping to indicate direction of flow using black stencil paint.

3.11 INSPECTION AND ACCEPTANCE

In addition to meeting previously specified requirements, demonstrate mobility of moving components, including swinging and sliding doors, cabinets, and windows with operable sash, for inspection by the Contracting Officer. Perform this demonstration after appropriate curing and drying times of coatings have elapsed and prior to invoicing for final payment.

3.12 WASTE MANAGEMENT

As specified in the Waste Management Plan and as follows. Do not use kerosene or any such organic solvents to clean up water based paints. Properly dispose of paints or solvents in designated containers. Close and seal partially used containers of paint to maintain quality as necessary for reuse. Store in protected, well-ventilated, fire-safe area at moderate temperature. Place materials defined as hazardous or toxic waste in designated containers. Set aside extra paint for future color matches or reuse by the Government.

3.13 MAINTENANCE INSTRUCTIONS

Provide one hard copy and one digital copy (.pdf - text searchable) of preprinted cleaning and maintenance instructions for all coating systems.

3.14 PAINT TABLES

All DFT's are minimum values. Use only materials having a minimum MPI "Environmentally Friendly" E1, E2, or E3 rating based on VOC (EPA Method 24) content levels. Acceptable products are listed in the MPI Green Approved Products List, available at http://www.specifygreen.com/APL/ProductIdxByMPInum.asp.

3.14.1 EXTERIOR PAINT TABLES

DIVISION 3: EXTERIOR CONCRETE PAINT TABLE

A. New and uncoated existing and Existing, previously painted concrete; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs:

1. Latex

New; MPI EXT 3.1A-G2 (Flat) / Existing; MPI REX 3.1A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 10	MPI 10	MPI 10

System DFT: 88 microns (3.5 mils)

New; MPI EXT 3.1A-G5 (Semigloss) / Existing; MPI EXT 3.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 11	MPI 11	MPI 11

System DFT: 88 microns (3.5 mils)

New; MPI EXT 3.1A-G6 (Gloss) / Existing; MPI REX 3.1A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 119	MPI 119	MPI 119

System DFT: 88 microns (3.5 mils)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces.

B. New and uncoated existing and Existing, previously painted concrete, textured system; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs:

1. Latex Aggregate

New; MPI EXT 3.1B-G2 (Flat) / Existing; MPI REX 3.1B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 10	MPI 10

System DFT: Per Manufacturer

New; MPI EXT 3.1B-G5 (Semigloss) / Existing; MPI REX 3.1B-G5 (Semigloss)

DIVISION 3: EXTERIOR CONCRETE PAINT TABLE

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 11	MPI 11

System DFT: Per Manufacturer

New; MPI EXT 3.1B-G6 (Gloss) / Existing; MPI REX 3.1B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 119	MPI 119

System DFT: Per Manufacturer

Texture - Fine, Medium, or Coarse. Surface preparation and number of coats in accordance with manufacturer's instructions. Topcoat: Coating to match adjacent surfaces.

C. New and uncoated existing and Existing, previously painted concrete, elastomeric System; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs:

1. Elastomeric Coating

New; MPI EXT 3.1F / Existing; MPI REX 3.1F

Primer:	Intermediate:	Topcoat:
Per Manufacturer	MPI 113	MPI 113

System DFT: 400 microns (16 mils)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. Surface preparation and number of coats in accordance with manufacturer's instructions.

NOTE: Apply sufficient coats of MPI 113 to achieve a minimum dry film thickness of 400 microns (16 mils).

D. New and uncoated existing and Existing, previously painted concrete: walls and bottom of swimming pools.

1. Chlorinated Rubber

New; / Existing;

Primer:	Intermediate:	Topcoat:
SSPC Paint 18	SSPC Paint 18	SSPC Paint 18

System DFT: Per Manufacturer

NOTE: Thin first coat (primer) with 1 part of approved thinner to 4 parts of paint by volume.

E. New and Existing Cementitious composition board (including Asbestos cement board):

1. Latex

New; MPI EXT 3.3A-G1 (Flat) /Existing; MPI REX 3.3A-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 10	MPI 10	MPI 10

System DFT: 112 microns (4.5 mils)

New; MPI EXT 3.3A-G5 (Semigloss) / Existing; MPI REX 3.3A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 11	MPI 11	MPI 11

System DFT: 112 microns (4.5 mils)

New; MPI EXT 3.3A-G6 (Gloss) / Existing; MPI REX 3.3A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:

DIVISION 3: EXTERIOR CONCRETE PAINT TABLE

MPI 119 MPI 119 MPI 119

System DFT: 112 microns (4.5 mils)

Topcoat: Coating to match adjacent surfaces.

DIVISION 4: EXTERIOR CONCRETE MASONRY UNITS PAINT TABLE

A. New and Existing concrete masonry on uncoated surface:

1. Latex

New; MPI EXT 4.2A-G1 (Flat) / Existing; MPI REX 4.2A-G1 (Flat)

Block Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 10	MPI 10

System DFT: 275 microns (11 mils)

New; MPI EXT 4.2A-G5 (Semigloss) / Existing; MPI REX 4.2A-G5 (Semigloss)

Block Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 11	MPI 11

System DFT: 275 microns (11 mils)

New; MPI EXT 4.2A-G6 (Gloss) / Existing; MPI REX 4.2A-G6 (Gloss)

Block Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 119	MPI 119

System DFT: 275 microns (11 mils)

Topcoat: Coating to match adjacent surfaces.

B. New and Existing concrete masonry, textured system; on uncoated surface:

1. Latex Aggregate

New; MPI EXT 4.2B-G1 (Flat) / Existing; MPI REX 4.2B-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 42	MPI 10

System DFT: Per Manufacturer

New; MPI EXT 4.2B-G5 (Semigloss) / Existing; MPI REX 4.2B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 42	MPI 11

System DFT: Per Manufacturer

New; MPI EXT 4.2B-G6 (Gloss) / Existing; MPI REX 4.2B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 42	MPI 119

System DFT: Per Manufacturer

Texture - Fine, Medium, or Coarse. Surface preparation and number of coats in accordance with manufacturer's instructions. Topcoat: Coating to match adjacent surfaces.

C. New and Existing concrete masonry, elastomeric system; on uncoated surface:

1. Elastomeric Coating

New; MPI EXT 4.2D / Existing; MPI REX 4.2D

Primer: Intermediate: Topcoat:

DIVISION 4: EXTERIOR CONCRETE MASONRY UNITS PAINT TABLE
Per Manufacturer MPI 113 MPI 113
System DFT: 400 microns (16 mils)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. Surface preparation and number of coats in accordance with manufacturer's instructions.

NOTE: Apply sufficient coats of MPI 113 to achieve a minimum dry film thickness of 400 microns (16 mils).

DIVISION 5: EXTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE

STEEL / FERROUS SURFACES

A. New Steel that has been hand or power tool cleaned to SSPC SP 2 or SSPC SP 3

1. Alkyd
New; MPI EXT 5.1Q-G5 (Semigloss) Existing; MPI REX 5.1D-G5

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 94	MPI 94

System DFT: 131 microns (5.25 mils)

New; MPI EXT 5.1Q-G6 (Gloss) / Existing; MPI REX 5.1D-G6

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 9	MPI 9

System DFT: 131 microns (5.25 mils)

B. New Steel that has been blast-cleaned to SSPC SP 6/NACE No.3:

2. Alkyd
New; MPI EXT 5.1D-G5 (Semigloss) / Existing; MPI REX 5.1D-G5

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 94	MPI 94

System DFT: 131 microns (5.25 mils)

New; MPI EXT 5.1D-G6 (Gloss) / Existing; MPI REX 5.1D-G6

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 9	MPI 9

System DFT: 131 microns (5.25 mils)

C. Existing steel that has been spot-blasted to SSPC SP 6/NACE No.3:

1. Surface previously coated with alkyd or latex:

Waterborne Light Industrial Coating
MPI REX 5.1C-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 79	MPI 163	MPI 163

System DFT: 125 microns (5 mils)

MPI REX 5.1C-G6 (Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 79	MPI 164	MPI 164

System DFT: 125 microns (5 mils)

2. Surface previously coated with epoxy:

STEEL / FERROUS SURFACES

Waterborne Light Industrial
a. MPI REX 5.1L-G5 (Semigloss)
Spot Primer: Intermediate: Topcoat:
MPI 101 MPI 163 MPI 163
System DFT: 125 microns (5 mils)

MPI REX 5.1L-G6 (Gloss)
Spot Primer: Intermediate: Topcoat:
MPI 101 MPI 164 MPI 164
System DFT: 125 microns (5 mils)

Pigmented Polyurethane
b. MPI REX 5.1H-G6 (Gloss)
Spot Primer: Intermediate: Topcoat:
MPI 101 MPI 108 MPI 72
System DFT: 212 microns (8.5 mils)

D. New and existing steel blast cleaned to SSPC SP 10/NACE No. 2:

1. Waterborne Light Industrial
MPI EXT 5.1R-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 108 MPI 163
System DFT: 212 microns (8.5 mils)

MPI EXT 5.1R-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 108 MPI 164
System DFT: 212 microns (8.5 mils)

2. Pigmented Polyurethane
MPI EXT 5.1J-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 108 MPI 72
System DFT: 212 microns (8.5 mils)

E. Metal floors (non-shop-primed surfaces or non-slip deck surfaces) with non-skid additive (NSA), load at manufacturer's recommendations.:

1. Alkyd Floor Enamel
MPI EXT 5.1S-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 79 MPI 27 MPI 27 (plus NSA)
System DFT: 131 microns (5.25 mils)

EXTERIOR GALVANIZED SURFACES

F. New Galvanized surfaces:

1. Cementitious primer / Latex
MPI EXT 5.3A-G1 (Flat)
Primer: Intermediate: Topcoat:
MPI 26 MPI 10 MPI 10
System DFT: 112 microns (4.5 mils)

MPI EXT 5.3A-G5 (Semigloss)
Primer: Intermediate: Topcoat:

EXTERIOR GALVANIZED SURFACES

MPI 26 MPI 11 MPI 11
System DFT: 112 microns (4.5 mils)

MPI EXT 5.3A-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 26 MPI 119 MPI 119
System DFT: 112 microns (4.5 mils)

2. Waterborne Primer / Latex
MPI EXT 5.3H-G1 (Flat)
Primer: Intermediate: Topcoat:
MPI 134 MPI 10 MPI 10
System DFT: 112 microns (4.5 mils)

MPI EXT 5.3H-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 134 MPI 11 MPI 11
System DFT: 112 microns (4.5 mils)

MPI EXT 5.3H-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 134 MPI 119 MPI 119
System DFT: 112 microns (4.5 mils)

3. Waterborne Primer / Waterborne Light Industrial Coating
MPI EXT 5.3J-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 134 MPI 163 MPI 163
System DFT: 112 microns (4.5 mils)

MPI EXT 5.3J-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 134 MPI 164 MPI 164
System DFT: 112 microns (4.5 mils)

4. Epoxy Primer / Waterborne Light Industrial Coating
MPI EXT 5.3K-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 163 MPI 163
System DFT: 125 microns (5 mils)

MPI EXT 5.3K-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 164 MPI 164
System DFT: 125 microns (5 mils)

5. Pigmented Polyurethane
MPI EXT 5.3L-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 101 N/A MPI 72
System DFT: 125 microns (5 mils)

G. Galvanized surfaces with slight coating deterioration; little or no rusting:

1. Waterborne Light Industrial Coating
MPI REX 5.3J-G5 (Semigloss)
Primer: Intermediate: Topcoat:

EXTERIOR GALVANIZED SURFACES

MPI 134 N/A MPI 163
System DFT: 112 microns (4.5 mils)

2. Pigmented Polyurethane
MPI REX 5.3D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	N/A	MPI 72

System DFT: 125 microns (5 mils)

H. Galvanized surfaces with severely deteriorated coating or rusting:

1. Waterborne Light Industrial Coating
MPI REX 5.3L-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 163

System DFT: 212 microns (8.5 mils)

MPI REX 5.3L-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 164

System DFT: 212 microns (8.5 mils)

2. Pigmented Polyurethane
MPI REX 5.3K-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 72

System DFT: 125 microns (5 mils)

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)

I. Aluminum, aluminum alloy and other miscellaneous non-ferrous metal items not otherwise specified except hot metal surfaces, roof surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd
MPI EXT 5.4F-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 8	MPI 8

System DFT: 125 microns (5 mils)

MPI EXT 5.4F-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 94	MPI 94

System DFT: 125 microns (5 mils)

MPI EXT 5.4F-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 9	MPI 9

System DFT: 125 microns (5 mils)

2. Waterborne Light Industrial Coating
MPI EXT 5.4G-G3(Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 161	MPI 161

System DFT: 125 microns (5 mils)

MPI EXT 5.4G-G5(Semigloss)

Primer: Intermediate: Topcoat:

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)

MPI 95 MPI 163 MPI 163

System DFT: 125 microns (5 mils)

MPI EXT 5.4G-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 164	MPI 164

System DFT: 125 microns (5 mils)

I. Existing roof surfaces previously coated:

1. Aluminum Pigmented Asphalt Roof Coating

ASTM D2824: Sufficient coats to provide not less than 200 microns(8 mils) of finished coating system (without asbestos fibers).

2. Aluminum Paint

MPI REX 10.2D

Primer:	Intermediate:	Topcoat:
MPI 107	MPI 1	MPI 1

System DFT: 88 microns (3.5 mils)

J. Surfaces adjacent to painted surfaces; Mechanical, Electrical, Fire extinguishing sprinkler systems including valves, conduit, hangers, supports, exposed copper piping, and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd

MPI EXT 5.1D-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 8	MPI 8

System DFT: 131 microns (5.25 mils)

MPI EXT 5.1D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 94	MPI 94

System DFT: 131 microns (5.25 mils)

MPI EXT 5.1D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 9	MPI 9

System DFT: 131 microns (5.25 mils)

2. Waterborne Light Industrial Coating

MPI EXT 5.1C-G3(Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 161	MPI 161

System DFT: 125 microns (5 mils)

MPI EXT 5.1C-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 163	MPI 163

System DFT: 125 microns (5 mils)

MPI EXT 5.1C-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 164	MPI 164

System DFT: 125 microns (5 mils)

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)

K. Hot metal surfaces including smokestacks subject to temperatures up to 205 degrees C (400 degrees F):

1. Heat Resistant Enamel
MPI EXT 5.2A
Primer: Intermediate: Topcoat:
MPI 21 Surface preparation and number of coats per manufacturer's instructions.
System DFT: Per Manufacturer

L. Ferrous metal subject to high temperature, up to 400 degrees C (750 degrees F):

1. Inorganic Zinc Rich Coating
MPI EXT 5.2C
Primer: Intermediate: Topcoat:
MPI 19 Surface preparation and number of coats per manufacturer's instructions.
System DFT: Per Manufacturer

2. Heat Resistant Aluminum Enamel
MPI EXT 5.2B (Aluminum Finish)
Primer: Intermediate: Topcoat:
MPI 2 Surface preparation and number of coats per manufacturer's instructions.
System DFT: Per Manufacturer

M. New surfaces and Existing surfaces made bare cleaning to SSPC SP 10/NACE No. 2 subject to temperatures up to 593 degrees C (1100 degrees F):

1. Heat Resistant Coating
MPI EXT 5.2D
Primer: Intermediate: Topcoat:
MPI 22 Surface preparation and number of coats per manufacturer's instructions.
System DFT: Per Manufacturer

DIVISION 6: EXTERIOR WOOD; DRESSED LUMBER, PANELING, DECKING, SHINGLES PAINT TABLE

A. New and Existing, uncoated Dressed lumber, Wood and plywood, trim, including top, bottom and edges of doors not otherwise specified:

1. Alkyd
MPI EXT 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 94	MPI 94

System DFT: 125 microns (5 mils)

MPI EXT 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 9	MPI 9

System DFT: 125 microns (5 mils)

2. Latex
MPI EXT 6.3A-G1 (Flat)

DIVISION 6: EXTERIOR WOOD; DRESSED LUMBER, PANELING, DECKING, SHINGLES
PAINT TABLE

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 10	MPI 10

System DFT: 125 microns (5 mils)

MPI EXT 6.3A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 11	MPI 11

System DFT: 125 microns (5 mils)

MPI EXT 6.3A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 119	MPI 119

System DFT: 125 microns (5 mils)

3. Waterborne Solid Color Stain
MPI EXT 6.3K

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 16	MPI 16

System DFT: 106 microns (4.25 mils)

B. Existing, dressed lumber, Wood and plywood, trim, including top, bottom and edges of doors previously coated with an alkyd / oil based finish coat not otherwise specified:

1. Alkyd
MPI REX 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 94	MPI 94

System DFT: 125 microns (5 mils)

MPI REX 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 9	MPI 9

System DFT: 125 microns (5 mils)

2. Latex
MPI REX 6.3A-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 10	MPI 10

System DFT: 125 microns (5 mils)

MPI REX 6.3A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 11	MPI 11

System DFT: 125 microns (5 mils)

MPI REX 6.3A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 119	MPI 119

System DFT: 125 microns (5 mils)

C. Existing, dressed lumber, Wood and plywood, trim, including top, bottom and edges of doors previously coated with a latex / waterborne finish coat not otherwise specified:

1. Latex
MPI REX 6.3L-G1 (Flat)

DIVISION 6: EXTERIOR WOOD; DRESSED LUMBER, PANELING, DECKING, SHINGLES
PAINT TABLE

Spot Primer: Intermediate: Topcoat:
MPI 6 MPI 10 MPI 10
System DFT: 112 microns (4.5 mils)

MPI REX 6.3L-G5 (Semigloss)
Spot Primer: Intermediate: Topcoat:
MPI 6 MPI 11 MPI 11
System DFT: 112 microns (4.5 mils)

MPI REX 6.3L-G6 (Gloss)
Spot Primer: Intermediate: Topcoat:
MPI 6 MPI 119 MPI 119
System DFT: 112 microns (4.5 mils)

2. Waterborne Solid Color Stain
MPI REX 6.3K (Stain)
Spot Primer: Intermediate: Topcoat:
MPI 6 MPI 16 MPI 16
System DFT: 100 microns (4 mils)

D. New, Uncoated wood siding:

1. Semi-Transparent Stain
MPI EXT 6.3D
Spot Primer: Intermediate: Topcoat:
N/A MPI 13 MPI 13
System DFT: N/A

E. Existing, previously stained wood siding:

1. Latex
MPI REX 6.2K-G1 (Flat)
Primer: Intermediate: Topcoat:
MPI 5 MPI 10 MPI 10
System DFT: 112 microns (4.5 mils)

MPI REX 6.2K-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 5 MPI 11 MPI 11
System DFT: 112 microns (4.5 mils)

F. Existing Uncoated or previously semitransparent stained wood siding:

1. Semi-Transparent Stain
MPI REX 6.3D
Spot Primer: Intermediate: Topcoat:
N/A MPI 13 MPI 13
System DFT: Per Manufacturer

G. Wood: Steps, platforms, floors of open porches with non-skid additive (NSA), load at manufacturer's recommendations:

1. Latex Floor Paint
MPI EXT 6.5A-G2 (Flat)
Primer: Intermediate: Topcoat:
MPI 5 MPI 60 MPI 60
System DFT: 112 microns (4.5 mils)

DIVISION 6: EXTERIOR WOOD; DRESSED LUMBER, PANELING, DECKING, SHINGLES PAINT TABLE

MPI EXT 6.5A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 68	MPI 68

System DFT: 112 microns (4.5 mils)

2. Alkyd Floor Paint

MPI EXT 6.5B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 59	MPI 59	MPI 59

System DFT: 125 microns (5 mils)

MPI EXT 6.5B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 27	MPI 27	MPI 27

System DFT: 125 microns (5 mils)

DIVISION 9: EXTERIOR STUCCO PAINT TABLE

A. New and Existing stucco:

1. Latex

New; MPI EXT 9.1A-G1 (Flat) / Existing; MPI REX 9.1A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 10	MPI 10	MPI 10

System DFT: 112 microns (4.5 mils)

New; MPI EXT 9.1A-G5 (Semigloss) / Existing; MPI REX 9.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 11	MPI 11	MPI 11

System DFT: 112 microns (4.5 mils)

New; MPI EXT 9.1A-G6 (Gloss) / Existing; MPI REX 9.1A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 119	MPI 119	MPI 119

System DFT: 112 microns (4.5 mils)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. On existing stucco, apply primer based on surface condition.

B. New and Existing stucco, elastomeric system:

1. Elastomeric Coating

New; MPI EXT 9.1C / Existing; MPI REX 9.1C

Primer:	Intermediate:	Topcoat:
N/A	MPI 113	MPI 113

System DFT: 400 microns (16 mils)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. Surface preparation and number of coats in accordance with manufacturer's instructions).

NOTE: Apply sufficient coats of MPI 113 to achieve a minimum dry film thickness of 400 microns (16 mils).

DIVISION 10: EXTERIOR CLOTH COVERINGS AND BITUMINOUS COATED SURFACES PAINT TABLE

A. Insulation and surfaces of insulation coverings (canvas, cloth, paper): (Interior and Exterior Applications)

1. Latex
MPI EXT 10.1A-G1 (Flat)

Primer:	Intermediate:	Topcoat:
N/A	MPI 10	MPI 10

System DFT: 80 microns (3.2 mils)

MPI EXT 10.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
N/A	MPI 11	MPI 11

System DFT: 80 microns (3.2 mils)

MPI EXT 10.1A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
N/A	MPI 119	MPI 119

System DFT: 80 microns (3.2 mils)

Topcoat: Coating to match adjacent surfaces.

3.14.2 INTERIOR PAINT TABLES

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

A. New and uncoated existing and Existing, previously painted Concrete, vertical surfaces, not specified otherwise:

1. Latex
New; MPI INT 3.1A-G2 (Flat) / Existing; MPI RIN 3.1A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 44	MPI 44

System DFT: 100 microns (4 mils)

New; MPI INT 3.1A-G3 (Eggshell) / Existing; MPI RIN 3.1A-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 52	MPI 52

System DFT: 100 microns (4 mils)

New; MPI INT 3.1A-G5 (Semigloss) / Existing; MPI RIN 3.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 54	MPI 54

System DFT: 100 microns (4 mils)

2. High Performance Architectural Latex
New; MPI INT 3.1C-G2 (Flat) / Existing; MPI RIN 3.1J-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 138	MPI 138

System DFT: 100 microns (4 mils)

New; MPI INT 3.1C-G3 (Eggshell) / Existing; MPI RIN 3.1J-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 139	MPI 139

System DFT: 100 microns (4 mils)

New; MPI INT 3.1C-G4 (satin)/ Existing; MPI RIN 3.1J-G4

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 140	MPI 140

System DFT: 100 microns (4 mils)

New; MPI INT 3.1C-G5 (Semigloss) / Existing; MPI RIN 3.1J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 141	MPI 141

System DFT: 100 microns (4 mils)

3. Institutional Low Odor / Low VOC Latex

New; MPI INT 3.1M-G2 (Flat) / Existing; MPI RIN 3.1L-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 144	MPI 144

System DFT: 100 microns (4 mils)

New; MPI INT 3.1M-G3 (Eggshell) / Existing; MPI RIN 3.1L-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 145	MPI 145

System DFT: 100 microns (4 mils)

New; MPI INT 3.1M-G4 (satin)/ Existing; MPI RIN 3.1L-G4

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 146	MPI 146

System DFT: 100 microns (4 mils)

New; MPI INT 3.1M-G5 (Semigloss) / Existing; MPI RIN 3.1L-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 147	MPI 147

System DFT: 100 microns (4 mils)

B. Concrete ceilings, uncoated:

1. Latex Aggregate

MPI INT 3.1N

Primer:	Intermediate:	Topcoat:
N/A	N/A	MPI 42

System DFT: Per Manufacturer

Texture - Fine, Medium, Coarse. Surface preparation, number of coats, and primer in accordance with manufacturer's instructions. Topcoat: Coating to match adjacent surfaces.

C. New and uncoated existing and Existing, previously painted Concrete in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation, and other high-humidity areas not otherwise specified except floors:

1. Waterborne Light Industrial Coating

New; MPI INT 3.1L-G3(Eggshell) / Existing; MPI RIN 3.1C-G3(Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 151	MPI 151	MPI 151

System DFT: 120 microns (4.8 mils)

New; MPI INT 3.1L-G5(Semigloss) / Existing; MPI RIN 3.1C-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 153	MPI 153	MPI 153

System DFT: 120 microns (4.8 mils)

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

New; MPI INT 3.1L-G6(Gloss) / Existing; MPI RIN 3.1C-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 154	MPI 154	MPI 154

System DFT: 120 microns (4.8 mils)

2. Alkyd

New; MPI INT 3.1D-G3 (Eggshell) / Existing; RIN 3.1D-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 51	MPI 51

System DFT: 112 microns (4.5 mils)

MPI INT 3.1D-G5 (Semigloss) / Existing; RIN 3.1D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

MPI INT 3.1D-G6 (Gloss) / Existing; RIN 3.1D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

3. Epoxy

New; MPI INT 3.1F-G6 (Gloss) / Existing; MPI RIN 3.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 77	MPI 77	MPI 77

System DFT: 100 microns (4 mils)

Note: Primer may be reduced for penetration per manufacturer's instructions.

D. New and uncoated existing and Existing, previously painted concrete walls and bottom of swimming pools:

1. Chlorinated Rubber

Primer:	Intermediate:	Topcoat:
SSPC Paint 18	SSPC Paint 18	SSPC Paint 18

System DFT: Per Manufacturer

Note: Primer may be reduced for penetration per manufacturer's instructions.

2. Epoxy

New; MPI INT 3.1F / Existing; MPI RIN 3.1E

Primer:	Intermediate:	Topcoat:
MPI 77	MPI 77	MPI 77

System DFT: 100 microns (4 mils)

Note: Primer may be reduced for penetration per manufacturer's instructions.

E. New and uncoated existing and Existing, previously painted concrete floors:

1. Latex Floor Paint

New; MPI INT 3.2A-G2 (Flat) / Existing; MPI RIN 3.2A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 60	MPI 60	MPI 60

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

System DFT: 125 microns (5 mils)

2. Alkyd Floor Paint
New; MPI INT 3.2B-G2 (Flat) / Existing; MPI RIN 3.2B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 59	MPI 59	MPI 59

System DFT: 125 microns (5 mils)

3. Epoxy
New; MPI INT 3.2C-G6 (Gloss) / Existing; MPI RIN 3.2C-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 77	MPI 77	MPI 77

System DFT: 125 microns (5 mils)

Note: Primer may be reduced for penetration per manufacturer's instructions.

DIVISION 4: INTERIOR CONCRETE MASONRY UNITS PAINT TABLE

A. New and uncoated Existing Concrete masonry:

1. High Performance Architectural Latex
MPI INT 4.2D-G2 (Flat)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 138	MPI 138

System DFT: 275 microns (11 mils)

MPI INT 4.2D-G3 (Eggshell)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 139	MPI 139

System DFT: 275 microns (11 mils)

MPI INT 4.2D-G4 (Satin)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 140	MPI 140

System DFT: 275 microns (11 mils)

MPI INT 4.2D-G5 (Semigloss)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 141	MPI 141

System DFT: 275 microns (11 mils)

Fill all holes in masonry surface

2. Institutional Low Odor / Low VOC Latex
New; MPI INT 4.2E-G2 (Flat)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 144	MPI 144

System DFT: 100 microns (4 mils)

New; MPI INT 4.2E-G3 (Eggshell)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 145	MPI 145

System DFT: 100 microns (4 mils)

New; MPI INT 4.2E-G4 (Satin)

Filler	Primer:	Intermediate:	Topcoat:

DIVISION 4: INTERIOR CONCRETE MASONRY UNITS PAINT TABLE

MPI 4	N/A	MPI 146	MPI 146

System DFT: 100 microns (4 mils)

New; MPI INT 4.2E-G5 (Semigloss)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 147	MPI 147

System DFT: 100 microns (4 mils)

B. Existing, previously painted Concrete masonry:

1. High Performance Architectural Latex

MPI RIN 4.2K-G2 (Flat)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 138	MPI 138

System DFT: 112 microns (4.5 mils)

MPI RIN 4.2K-G3 (Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 139	MPI 139

System DFT: 112 microns (4.5 mils)

MPI RIN 4.2K-G4

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 140	MPI 140

System DFT: 112 microns (4.5 mils)

MPI RIN 4.2K-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 141	MPI 141

System DFT: 112 microns (4.5 mils)

2. Institutional Low Odor / Low VOC Latex

Existing; MPI RIN 4.2L-G2 (Flat)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 144	MPI 144

System DFT: 100 microns (4 mils)

Existing; MPI RIN 4.2L-G3 (Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 145	MPI 145

System DFT: 100 microns (4 mils)

Existing; MPI RIN 4.2L-G4 (Satin)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 146	MPI 146

System DFT: 100 microns (4 mils)

Existing; MPI RIN 4.2L-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 147	MPI 147

System DFT: 100 microns (4 mils)

C. New and uncoated Existing Concrete masonry units in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation, and other high humidity areas unless otherwise specified:

1. Waterborne Light Industrial Coating

DIVISION 4: INTERIOR CONCRETE MASONRY UNITS PAINT TABLE

MPI INT 4.2K-G3(Eggshell)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 151	MPI 151

System DFT: 275 microns (11 mils)

MPI INT 4.2K-G5(Semigloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 153	MPI 153

System DFT: 275 microns (11 mils)

MPI INT 4.2K-G6(Gloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 154	MPI 154

System DFT: 275 microns (11 mils)

Fill all holes in masonry surface

2. Alkyd

MPI INT 4.2N-G3 (Eggshell)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	MPI 50	MPI 51	MPI 51

System DFT: 300 microns (12 mils)

MPI INT 4.2N-G5 (Semigloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	MPI 50	MPI 47	MPI 47

System DFT: 300 microns (12 mils)

MPI INT 4.2N-G6 (Gloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	MPI 50	MPI 48	MPI 48

System DFT: 300 microns (12 mils)

Fill all holes in masonry surface

3. Epoxy

MPI INT 4.2G-G6 (Gloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 116	N/A	MPI 77	MPI 77

System DFT: 250 microns (10 mils)

Fill all holes in masonry surface

D. Existing, previously painted, concrete masonry units in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation, and other high humidity areas unless otherwise specified:

1. Waterborne Light Industrial Coating

MPI RIN 4.2G-G3(Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 151	MPI 151	MPI 151

System DFT: 112 microns (4.5 mils)

MPI RIN 4.2G-G5(Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 153	MPI 153	MPI 153

System DFT: 112 microns (4.5 mils)

DIVISION 4: INTERIOR CONCRETE MASONRY UNITS PAINT TABLE

MPI RIN 4.2G-G6(Gloss)
Spot Primer: Intermediate: Topcoat:
MPI 154 MPI 154 MPI 154
System DFT: 112 microns (4.5 mils)

2. Alkyd
MPI RIN 4.2C-G3 (Eggshell)
Spot Primer: Intermediate: Topcoat:
MPI 50 MPI 51 MPI 51
System DFT: 112 microns (4.5 mils)

MPI RIN 4.2C-G5 (Semigloss)
Spot Primer: Intermediate: Topcoat:
MPI 50 MPI 47 MPI 47
System DFT: 112 microns (4.5 mils)

MPI RIN 4.2C-G6 (Gloss)
Spot Primer: Intermediate: Topcoat:
MPI 50 MPI 48 MPI 48
System DFT: 112 microns (4.5 mils)

3. Epoxy
MPI RIN 4.2D-G6 (Gloss)
Spot Primer: Intermediate: Topcoat:
MPI 77 MPI 77 MPI 77
System DFT: 125 microns (5 mils)

DIVISION 5: INTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE

INTERIOR STEEL / FERROUS SURFACES

A. Metal, Mechanical, Electrical, Fire extinguishing sprinkler systems including valves, conduit, hangers, supports, Surfaces adjacent to painted surfaces (Match surrounding finish), exposed copper piping, and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment:

1. High Performance Architectural Latex
MPI INT 5.1R-G2 (Flat)
Primer: Intermediate: Topcoat:
MPI 79 MPI 138 MPI 138
System DFT: 125 microns (5 mils)

MPI INT 5.1R-G3 (Eggshell)
Primer: Intermediate: Topcoat:
MPI 79 MPI 139 MPI 139
System DFT: 125 microns (5 mils)

MPI INT 5.1R-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 79 MPI 141 MPI 141
System DFT: 125 microns (5 mils)

2. Alkyd
MPI INT 5.1E-G2 (Flat)

INTERIOR STEEL / FERROUS SURFACES

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 49	MPI 49

System DFT: 131 microns (5.25 mils)

MPI INT 5.1E-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 51	MPI 51

System DFT: 131 microns (5.25 mils)

MPI INT 5.1E-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 47	MPI 47

System DFT: 131 microns (5.25 mils)

MPI INT 5.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 48	MPI 48

System DFT: 131 microns (5.25 mils)

B. Metal floors (non-shop-primed surfaces or non-slip deck surfaces) with non-skid additive (NSA), load at manufacturer's recommendations.:

1. Alkyd Floor Paint
MPI INT 5.1U-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 27	MPI 27 (plus NSA)

System DFT: 131 microns (5.25 mils)

2. Epoxy
MPI INT 5.1L-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 77	MPI 77 (plus NSA)

System DFT: 131 microns (5.25 mils)

C. Metal in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation, and other high-humidity areas not otherwise specified except floors, hot metal surfaces, and new prefinished equipment:

1. Alkyd
MPI INT 5.1E-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 51	MPI 51

System DFT: 131 microns (5.25 mils)

MPI INT 5.1E-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 47	MPI 47

System DFT: 131 microns (5.25 mils)

MPI INT 5.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 48	MPI 48

System DFT: 131 microns (5.25 mils)

2. Alkyd
MPI INT 5.1T-G3 (Eggshell) For hand tool cleaning

INTERIOR STEEL / FERROUS SURFACES

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 51	MPI 51

System DFT: 131 microns (5.25 mils)

MPI INT 5.1T-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 47	MPI 47

System DFT: 131 microns (5.25 mils)

MPI INT 5.1T-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 48	MPI 48

System DFT: 131 microns (5.25 mils)

D. Ferrous metal in concealed damp spaces or in exposed areas having unpainted adjacent surfaces.

1. Aluminum Paint

MPI INT 5.1M

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 1	MPI 1

System DFT: 106 microns (4.25 mils)

E. Miscellaneous non-ferrous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish:

1. High Performance Architectural Latex

MPI INT 5.4F-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 138	MPI 138

System DFT: 125 microns (5 mils)

MPI INT 5.4F-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 139	MPI 139

System DFT: 125 microns (5 mils)

MPI INT 5.4F-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 140	MPI 140

System DFT: 125 microns (5 mils)

MPI INT 5.4F-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 141	MPI 141

System DFT: 125 microns (5 mils)

2. Alkyd

MPI INT 5.4J-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 49	MPI 49

System DFT: 125 microns (5 mils)

MPI INT 5.4J-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 51	MPI 51

INTERIOR STEEL / FERROUS SURFACES
System DFT: 125 microns (5 mils)

MPI INT 5.4J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 47	MPI 47

System DFT: 125 microns (5 mils)

MPI INT 5.4J-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 48	MPI 48

System DFT: 125 microns (5 mils)

F. Hot metal surfaces including smokestacks subject to temperatures up to 205 degrees C (400 degrees F):

1. Heat Resistant Enamel
   MPI INT 5.2A
   Primer: Intermediate: Topcoat:
   MPI 21 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

G. Ferrous metal subject to high temperature, up to 400 degrees C (750 degrees F):

1. Inorganic Zinc Rich Coating
   MPI INT 5.2C
   Primer: Intermediate: Topcoat:
   MPI 19 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

2. Heat Resistant Aluminum Paint
   MPI INT 5.2B (Aluminum Finish)
   Primer: Intermediate: Topcoat:
   MPI 2 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

H. New surfaces and Existing surfaces made bare cleaning to SSPC SP 10/NACE No. 2 subject to temperatures up to 593 degrees C (1100 degrees F):

1. High Heat Resistant Coating
   MPI INT 5.2D
   Primer: Intermediate: Topcoat:
   MPI 22 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

DIVISION 6: INTERIOR WOOD PAINT TABLE

A. New and Existing, uncoated Wood and plywood not otherwise specified:

1. High Performance Architectural Latex
   MPI INT 6.4S-G3 (Eggshell)
   Primer: Intermediate: Topcoat:

DIVISION 6: INTERIOR WOOD PAINT TABLE

MPI 39	MPI 139	MPI 139

System DFT: 112 microns (4.5 mils)

MPI INT 6.4S-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 140	MPI 140

System DFT: 112 microns (4.5 mils)

MPI INT 6.4S-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 141	MPI 141

System DFT: 112 microns (4.5 mils)

2. Alkyd

MPI INT 6.4B-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 51	MPI 51

System DFT: 112 microns (4.5 mils)

MPI INT 6.4B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

MPI INT 6.4B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

3. Institutional Low Odor / Low VOC Latex

New; MPI INT 6.3V-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 144	MPI 144

System DFT: 100 microns (4 mils)

New; MPI INT 6.3V-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 145	MPI 145

System DFT: 100 microns (4 mils)

New; MPI INT 6.3V-G4

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 146	MPI 146

System DFT: 100 microns (4 mils)

New; MPI INT 6.3V-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 147	MPI 147

System DFT: 100 microns (4 mils)

B. Existing, previously painted Wood and plywood not otherwise specified:

1. High Performance Architectural Latex

MPI RIN 6.4B-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 139	MPI 139

System DFT: 1123 microns (4.5 mils)

DIVISION 6: INTERIOR WOOD PAINT TABLE

MPI RIN 6.4B-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 140	MPI 140

System DFT: 112 microns (4.5 mils)

MPI RIN 6.4B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 141	MPI 141

System DFT: 112 microns (4.5 mils)

2. Alkyd

MPI RIN 6.4C-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 51	MPI 51

System DFT: 112 microns (4.5 mils)

MPI RIN 6.4C-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

MPI RIN 6.4C-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

3. Institutional Low Odor / Low VOC Latex

Existing; MPI RIN 6.4D-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 144	MPI 144

System DFT: 100 microns (4 mils)

Existing; MPI RIN 6.4D-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 145	MPI 145

System DFT: 100 microns (4 mils)

Existing; MPI RIN 6.4D-G4

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 146	MPI 146

System DFT: 100 microns (4 mils)

Existing; MPI RIN 6.4D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 147	MPI 147

System DFT: 100 microns (4 mils)

C. New and Existing, previously finished or stained Wood and Plywood, except floors; natural finish or stained:

1. Natural finish, oil-modified polyurethane

New; MPI INT 6.4J-G4 / Existing; MPI RIN 6.4L-G4

Primer:	Intermediate:	Topcoat:
MPI 57	MPI 57	MPI 57

System DFT: 100 microns (4 mils)

New; MPI INT 6.4J-G6 (Gloss) / Existing; MPI RIN 6.4L-G6 (Gloss)

Primer:	Intermediate:	Topcoat:

DIVISION 6: INTERIOR WOOD PAINT TABLE

MPI 56 MPI 56 MPI 56
System DFT: 100 microns (4 mils)

2. Stained, oil-modified polyurethane
New; MPI INT 6.4E-G4 / Existing; MPI RIN 6.4G-G4

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 57	MPI 57	MPI 57

System DFT: 100 microns (4 mils)

New; MPI INT 6.4E-G6 (Gloss) / Existing; MPI RIN 6.4G-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 56	MPI 56	MPI 56

System DFT: 100 microns (4 mils)

3. Stained, Moisture Cured Urethane
New; MPI INT 6.4V-G2 (Flat) / Existing; MPI RIN 6.4V-G2 (Flat)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 71	MPI 71	MPI 71

System DFT: 100 microns (4 mils)

New; MPI INT 6.4V-G6 (Gloss) / Existing; MPI RIN 6.4V-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 31	MPI 31	MPI 31

System DFT: 100 microns (4 mils)

D. New and Existing, previously finished or stained Wood Floors; Natural finish or stained:

1. Natural finish, oil-modified polyurethane
New; MPI INT 6.5C-G6 (Gloss) / Existing; MPI RIN 6.5C-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 56	MPI 56	MPI 56

System DFT: 100 microns (4 mils)

2. Natural finish, Moisture Cured Polyurethane
New; MPI INT 6.5K-G6 (Gloss) / Existing; MPI RIN 6.5D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 31	MPI 31	MPI 31

System DFT: 100 microns (4 mils)

3. Stained, oil-modified polyurethane
New; MPI INT 6.5B-G6 (Gloss) / Existing; MPI RIN 6.5B-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 56	MPI 56	MPI 56

System DFT: 100 microns (4 mils)

4. Stained, Moisture Cured Polyurethane
New; MPI INT 6.5J-G6 (Gloss) / Existing; MPI RIN 6.5L-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 31	MPI 31	MPI 31

System DFT: 100 microns (4 mils)

E. New and Existing, previously coated Wood floors; pigmented finish:

1. Latex Floor Paint
New; MPI INT 6.5G-G2 (Flat) / Existing; MPI RIN 6.5J-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 60	MPI 60

DIVISION 6: INTERIOR WOOD PAINT TABLE

System DFT: 112 microns (4.5 mils)

New; MPI INT 6.5G-G6 (Gloss) / Existing; MPI RIN 6.5J-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 68	MPI 68

System DFT: 1123 microns (4.5 mils)

2. Alkyd Floor Paint

New; MPI INT 6.5A-G2 (Flat) / Existing; MPI RIN 6.5A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 59	MPI 59	MPI 59

System DFT: 112 microns (4.5 mils)

New; MPI INT 6.5A-G6 (Gloss) / Existing; MPI RIN 6.5A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 27	MPI 27	MPI 27

System DFT: 112 microns (4.5 mils)

F. New and Existing, uncoated wood surfaces in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas not otherwise specified.:

1. Waterborne Light Industrial

MPI INT 6.3P-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 153	MPI 153

System DFT: 112 microns (4.5 mils)

MPI INT 6.3P-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 154	MPI 154

System DFT: 112 microns (4.5 mils)

2. Alkyd

MPI INT 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

MPI INT 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

G. Existing, previously painted wood surfaces in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas not otherwise specified:

1. Waterborne Light Industrial Coating

MPI RIN 6.3P-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 153	MPI 153

System DFT: 112 microns (4.5 mils)

MPI RIN 6.3P-G6 (Gloss)

Primer:	Intermediate:	Topcoat:

DIVISION 6: INTERIOR WOOD PAINT TABLE

MPI 46 | MPI 154 | MPI 154

System DFT: 112 microns (4.5 mils)

2. Alkyd

MPI RIN 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

MPI RIN 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

H. New and Existing, previously finished or stained Wood Doors; Natural Finish or Stained:

1. Natural finish, oil-modified polyurethane

New; MPI INT 6.3K-G4 / Existing; MPI RIN 6.3K-G4

Primer:	Intermediate:	Topcoat:
MPI 57	MPI 57	MPI 57

System DFT: 100 microns (4 mils)

New; MPI INT 6.3K-G6 (Gloss) / Existing; MPI RIN 6.3K-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 56	MPI 56	MPI 56

System DFT: 100 microns (4 mils)

Note: Sand between all coats per manufacturers recommendations.

2. Stained, oil-modified polyurethane

New; MPI INT 6.3E-G4 / Existing; MPI RIN 6.3E-G4

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 57	MPI 57	MPI 57

System DFT: 100 microns (4 mils)

New; MPI INT 6.3E-G6 (Gloss) / Existing; MPI RIN 6.3E-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 56	MPI 56	MPI 56

System DFT: 100 microns (4 mils)

Note: Sand between all coats per manufacturers recommendations.

3. Stained, Moisture Cured Urethane

New; MPI INT 6.4V-G2 (Flat) / Existing; MPI RIN 6.4V-G2 (Flat)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 71	MPI 71	MPI 71

System DFT: 100 microns (4 mils)

New; MPI INT 6.4V-G6 (Gloss) / Existing; MPI RIN 6.4V-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 31	MPI 31	MPI 31

System DFT: 100 microns (4 mils)

Note: Sand between all coats per manufacturers recommendations.

I. New and Existing, uncoated Wood Doors; Pigmented finish:

DIVISION 6: INTERIOR WOOD PAINT TABLE

1. Alkyd

New; MPI INT 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

New; MPI INT 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

Note: Sand between all coats per manufacturers recommendations.

2. Pigmented Polyurethane

New; MPI INT 6.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 72	MPI 72	MPI 72

System DFT: 112 microns (4.5 mils)

Note: Sand between all coats per manufacturers recommendations.

J. Existing, previously painted Wood Doors; Pigmented finish:

1. Alkyd

New; MPI RIN 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 47	MPI 47

System DFT: 112 microns (4.5 mils)

New; MPI RIN 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 48	MPI 48

System DFT: 112 microns (4.5 mils)

Note: Sand between all coats per manufacturers recommendations.

DIVISION 9: INTERIOR PLASTER, GYPSUM BOARD, TEXTURED SURFACES PAINT TABLE

A. New and Existing, previously painted Plaster and Wallboard not otherwise specified:

1. Latex

New; MPI INT 9.2A-G2 (Flat) / Existing; RIN 9.2A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 44	MPI 44

System DFT: 100 microns (4 mils)

New; MPI INT 9.2A-G3 (Eggshell) / Existing; RIN 9.2A-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 52	MPI 52

System DFT: 100 microns (4 mils)

New; MPI INT 9.2A-G5 (Semigloss) / Existing; RIN 9.2A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 54	MPI 54

System DFT: 100 microns (4 mils)

DIVISION 9: INTERIOR PLASTER, GYPSUM BOARD, TEXTURED SURFACES PAINT TABLE

2. High Performance Architectural Latex - High Traffic Areas
   New; MPI INT 9.2B-G2 (Flat) / Existing; MPI RIN 9.2B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 138	MPI 138

   System DFT: 100 microns (4 mils)

   New; MPI INT 9.2B-G3 (Eggshell) / Existing; MPI RIN 9.2B-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 139	MPI 139

   System DFT: 100 microns (4 mils)

   New; MPI INT 9.2B-G5 (Semigloss) / Existing; MPI RIN 9.2B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 141	MPI 141

   System DFT: 100 microns (4 mils)

3. Institutional Low Odor / Low VOC Latex
   New; MPI INT 9.2M-G2 (Flat) / Existing; MPI RIN 9.2M-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 144	MPI 144

   System DFT: 100 microns (4 mils)

   New; MPI INT 9.2M-G3 (Eggshell) / Existing; MPI RIN 9.2M-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 145	MPI 145

   System DFT: 100 microns (4 mils)

   New; MPI INT 9.2M-G4 (Satin) / Existing; MPI RIN 9.2M-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 146	MPI 146

   System DFT: 100 microns (4 mils)

   New; MPI INT 9.2M-G5 (Semigloss) / Existing; MPI RIN 9.2M-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 147	MPI 147

   System DFT: 100 microns (4 mils)

B. New and Existing, previously painted Plaster and Wallboard in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas not otherwise specified.:

1. Waterborne Light Industrial Coating
   New; MPI INT 9.2L-G5(Semigloss) / Existing; MPI RIN 9.2L-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 153	MPI 153

   System DFT: 100 microns (4 mils)

2. Alkyd
   New; MPI INT 9.2C-G5 (Semigloss) / Existing; MPI RIN 9.2C-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 47	MPI 47

   System DFT: 100 microns (4 mils)

3. Epoxy
   New; MPI INT 9.2E-G6 (Gloss) / Existing; MPI RIN 9.2D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:

DIVISION 9: INTERIOR PLASTER, GYPSUM BOARD, TEXTURED SURFACES PAINT TABLE

MPI 50 MPI 77 MPI 77

System DFT: 100 microns (4 mils)

-- End of Section --

SECTION 10 14 01

EXTERIOR SIGNAGE
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1	(2009; Errata 2010) Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

AMERICAN WELDING SOCIETY (AWS)

AWS C1.1M/C1.1	(2012) Recommended Practices for Resistance Welding
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2008) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A1011/A1011M	(2014) Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet,

	Metallic-Coated by the Hot-Dip Process
ASTM B108/B108M	(2014) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM C1036	(2010; E 2012) Standard Specification for Flat Glass
ASTM D3841	(1997; E 2008; R 2008) Standard Specification for Glass Fiber-Reinforced Polyester Plastic Panels
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM AMP 500	(2006) Metal Finishes Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS3611	(2011; Rev E) Plastic Sheet, Polycarbonate General Purpose

1.2 GENERAL REQUIREMENTS

All exterior signage shall be provided by a single manufacturer. Exterior signage shall be of the design, detail, sizes, types, and message content shown on the drawings, shall conform to the requirements specified, and shall be provided at the locations indicated. Submit exterior signage schedule in electronic media with spread sheet format. Spread sheet shall include sign location, sign type, and message. Signs shall be complete with lettering, framing as detailed, and related components for a complete installation. Each sample shall consist of a complete sign panel with letters and symbols. Samples may be installed in the work, provided each sample is identified and location recorded.

1.2.1 Wind Load Requirements

Exterior signage shall be designed to withstand 190 km/h 120 mph windload. Submit design analysis and supporting calculations performed in support of specified signage.

1.2.2 Character Proportions and Heights

Letters and numbers on indicated signs for handicapped-accessible buildings shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10. Characters and numbers on indicated signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper case letter "X". Lower case characters are permitted.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings

SD-03 Product Data

Exterior Signage
Wind Load Requirements

1.4 QUALIFICATIONS

Signs, plaques, and dimensional letters shall be the standard product of a manufacturer regularly engaged in the manufacture of the products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

1.5 DELIVERY AND STORAGE

Materials shall be wrapped for shipment and storage, delivered to the jobsite in manufacturer's original packaging, and stored in a clean, dry area in accordance with manufacturer's instructions.

1.6 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided.

PART 2 PRODUCTS

2.1 MODULAR EXTERIOR SIGNAGE SYSTEM

Exterior signage shall consist of a system of coordinated directional, identification, and regulatory type signs located where shown. Dimensions, details, materials, message content, and design of signage shall be as shown.

2.1.1 Free-Standing Base Mount Pylon/Monolith Type Signs

2.1.1.1 Framing

Interior framing shall consist of aluminum or galvanized steel tube columns welded to companion plates. Perimeter framing shall consist of aluminum or steel angle framing welded to the post and plate system as designed. Framing members shall be designed to permit access to electrical equipment and panel removal. Mounting shall be provided as shown. Framing members of steel shall be finished with semi-gloss baked enamel or two-component acrylic polyurethane. Openings shall be sealed from moisture and made tamper-proof.

2.1.1.2 Exterior Sheeting Panels

Modular panels shall be provided in sizes shown on drawings. Panels shall be fabricated a minimum of 2.3 mm 0.090 inch thick aluminum or steel, or 3.2 mm 0.125 inch thick fiberglass reinforced plastic (FRP). Top and end panels shall be removable and shall be secured by 5 mm 3/16 inch socket head jack nuts. Finish for metal panels shall be semi-gloss baked enamel or two-component acrylic polyurethane.

2.1.1.3 Mounting

Mounting shall be provided by securing to concrete foundation as shown.

2.1.1.4 Finishes

Base finish shall be semi-gloss baked enamel or two-component acrylic polyurethane. Metal panel system finish shall be baked enamel or two-component acrylic polyurethane.

2.1.2 Panel And Post/Panel Type Signs

2.1.2.1 Posts

One-piece aluminum or galvanized steel posts shall be provided with minimum 3.2 mm 0.125 inch wall thickness. Posts shall be designed to accept panel framing system described. The post shall be designed to permit attachment of panel framing system without exposed fasteners. Caps shall be provided for each post.

2.1.2.2 Panel Framing System

Panel framing consisting of aluminum sections and interlocking track components shall be designed to interlock with posts with concealed fasteners.

2.1.2.3 Panels

Modular message panels shall be provided in sizes shown on drawings. Panels shall be fabricated a minimum of 2.3 mm 0.090 inch aluminum, 3.2 mm 0.125 inch acrylic, or 3.2 mm 0.125 inch fiberglass reinforced plastic (FRP). Panels with metal return sheeting shall have welded corners, ground smooth.

2.1.2.4 Finishes

Post finish shall be semi-gloss baked enamel or two-component acrylic polyurethane. Metal panel system finish shall be baked enamel or two-component acrylic polyurethane.

2.1.2.5 Mounting

Permanent mounting shall be provided by embedding posts in concrete foundation as shown. Removable mounting shall be provided by a steel or an aluminum sleeve flange embedded in concrete if the design requires.

2.1.3 Changeable Letter Directories

2.1.3.1 Frame and Trim

Aluminum alloy finish shall be anodized conforming to AA DAF45.

2.1.3.2 Header Plates

Header plate shall consist of background metal matching frame and having raised letters attached through the back, acrylic with raised acrylic letters, or MP plastic with raised letters.

2.1.3.3 Door Glazing

Door glazing shall be clear safety or tempered glass minimum 6 mm 1/4 inch thick, clear acrylic sheet 4.8 mm 3/16 inch thick, or clear polycarbonate sheet 6.4 mm 1/4 inch thick.

2.1.3.4 Door Construction

Door frame shall be of same material and finish as surrounding frame. Corners shall be mitered, reinforced, welded, and assembled with concealed fasteners. Hinges shall be standard with manufacturer, in finish to match frames and trim. Glazing shall be set in frame with resilient glazing channels.

2.1.3.5 Door Locks

Door locks shall be manufacturer's standard and shall be keyed alike.

2.1.3.6 Fabrication

Frames and trim shall be assembled with corners reinforced or welded and mitered to hairline fit, with no exposed fasteners. Removable changeable directory panel shall consist of 6 mm 1/4 inch thick white acrylic with clear acrylic letter tracks back with vinyl or polycarbonate covering back-grooved 6 mm 1/4 inch on centers to receive letters.

2.1.3.7 Finishes

Post finish shall be semi-gloss baked enamel or two-component acrylic polyurethane. Metal panel system finish shall be baked enamel or two-component acrylic polyurethane.

2.1.3.8 Mounting

Directories shall be mounted to supporting structures with concealed fasteners in accordance with manufacturer's instructions.

2.1.3.9 Changeable Letters

Changeable letters shall be upper-case or upper and lower-case helvetica medium. Tabbed vinyl letters and numbers shall be furnished in accordance with the drawings.

2.2 ILLUMINATION

Concealed lighting shall be provided within panel framing members. Lighting shall be controlled by a photocell device. Top or back lighting shall be provided by T-12 slimline lamps, 120 volt, 60-hertz, single-phase, Type 1, or Type 2 ballast. Ballast shall be integrally mounted, high power factor and rated for use down to minus 29 degrees C minus 20 degrees F ambient starting temperature. Ballast and wiring within the sign shall be in metal raceways. Electrical equipment shall be UL or FM listed and comply with NFPA 70. Illumination shall be evenly distributed. A switch on the interior of the sign shall be provided to turn off power in the sign. Switch shall be readily accessible when sign is open.

2.3 GRAPHICS FOR EXTERIOR SIGNAGE SYSTEMS

2.3.1 Graphics

Signage graphics shall conform to the following:

a. Cast, custom fabricated, or plate aluminum letters, 13 mm 1/2 inch thick shall be provided and fastened to the message panel with concealed fasteners.

b. Message shall be cut out from panel. Acrylic letters 13 mm (1/2 inch) 1/2 inchthick shall be projected through the cutout area and chemically welded to 3.2 mm (0.125 inch) 0.125 inch thick acrylic backup sheet.

2.4 METAL PLAQUES

Design and location of plaques shall be as shown.

2.4.1 Cast Metal Plaques

2.4.1.1 Fabrication

Cast metal plaques shall have the logo, emblem and artwork cast in the flat relief technique. Plaques shall be fabricated from prime aluminum, ,bronze, or yellow brass.

2.4.1.2 Size

Plaque size shall be as shown.

2.4.1.3 Border

Border shall be bevel.

2.4.1.4 Background

Background texture shall be leather.

2.4.1.5 Mounting

Mounting shall be concealed.

2.4.1.6 Finish

Finishes shall consist of one of the followings as indicated:

Aluminum light colored sandblasted background. Letters shall be satin polished and entire plaque shall be sprayed with two coats of clear lacquer.

Aluminum with background sprayed dark gunmetal colored lacquer. Letters shall be satin polished and entire plaque sprayed with two coats clear lacquer.

Bronze with dark finish oxidized background. Letters shall be satin polished and entire plaque sprayed with two coats of clear lacquer.

Aluminum or bronze with sprayed background. Letters shall be satin polished.

2.4.2 Chemically Etched Metal Plaques

2.4.2.1 Fabrication

Plaque shall be chemically single- or double- etched one-piece brass or bronze 1.6256 mm 0.064 inch thick.

2.4.2.2 Size

Plaque size shall be as shown.

2.4.2.3 Finish

Single-etched raised areas shall be in gold-tone, silver-tone, or bronze-tone finish and recessed areas shall be color-filled. Double-etched raised areas shall be gold-tone or silver-tone and recessed textured areas shall be gold-tone or silver-tone color-filled.

2.4.3 Frost and Surface Oxidized Plaques

2.4.3.1 Fabrication

Plaque shall be frosted and surface oxidized one - piece anodized aluminum, brass, bronze, or stainless steel 3.175 mm 0.125 inch thick.

2.4.3.2 Size

Plaque size shall be as shown.

2.4.3.3 Finish

Material finish shall be satin or polished. Frosted areas shall be oxidized black for aluminum or stainless steel or black or brown, for brass or bronze.

2.5 DIMENSIONAL BUILDING LETTERS

2.5.1 Fabrication

Letters shall be fabricated from cast aluminum or cast bronze 2.29 mm 0.090 inch aluminum sheet. Letters shall be cleaned by chemical etching or cleaned ultrasonically in a special degreasing bath. Letters shall be packaged for protection until installation.

2.5.2 Typeface

Typeface shall be helvetica medium.

2.5.3 Size

Letter size shall be as indicated.

2.5.4 Finish

Anodized aluminum or baked enamel, or two-component acrylic polyurethane. Or, polished or oxidized bronze with clear coat, as indicated.

2.5.5 Mounting

Threaded studs or steel U-bracket, cap screws, and expansion bolts of number and size as recommended by manufacturer, shall be used for concealed anchorage. Letters which project from the building line shall have stud spacer sleeves. Letters, studs, and sleeves shall be of the same material. Templates for mounting shall be supplied.

2.6 ALUMINUM ALLOY PRODUCTS

Aluminum alloy products shall conform to ASTM B209M ASTM B209 for sheet or plate, ASTM B221M ASTM B221 for extrusions and ASTM B26/B26M or ASTM B108/B108M for castings. Aluminum extrusions shall be provided at least 3 mm 1/8 inch thick and aluminum plate or sheet at least 16 gauge thick. Welding for aluminum products shall conform to AWS C1.1M/C1.1.

2.7 ANODIC COATING

Anodized finish shall conform to AA DAF45 as follows:

Clear (natural) designation AA-M10-C22-A31, Architectural Class II 0.010 mm 0.4 mil or thicker,

Integrated color anodized designation AA-M10-C22-A32, Architectural Class 0.010 to 0.018 mm 0.4 to 0.7 mil, or

Electrolytically deposited color - anodized designation

AA-M10-C22-A34, Architectural Class II 0.010 to 0.018 mm 0.4 to 0.7 mil.

2.8 ORGANIC COATING

Surfaces shall be cleaned, primed, and given a semi-gloss baked enamel or two-component acrylic polyurethane finish in accordance with NAAMM AMP 500, AMP 505, with total dry film thickness not less than 0.030 mm 1.2 mils.

2.9 STEEL PRODUCTS

Structural steel products shall conform to ASTM A36/A36M. Sheet and strip steel products shall conform to ASTM A1011/A1011M. Welding for steel products shall conform to AWS D1.2/D1.2M.

2.10 CAST BRONZE

Components shall be fabricated with sharp corners, flat faces, and accurate profiles. Burrs and rough spots shall be removed and polished. Faces shall be finished to a uniform high luster. Cast bronze shall be in accordance with ASTM B62.

2.11 VINYL SHEETING FOR GRAPHICS

Vinyl sheeting shall be 5 to 7 year premium type and shall be in accordance with the flammability requirements of ASTM E84 and shall be a minimum 0.08 mm 0.003 inch film thickness. Film shall include a precoated pressure sensitive adhesive backing, Class 1, or positionable pressure sensitive adhesive backing, Class 3.

2.12 GLASS

Glass shall be in accordance with ASTM C1036, Type I, Class 1, Quality q3 and ANSI Z97.1.

2.13 FIBER-REINFORCED POLYESTER (FRP) PANELS

Fiber-reinforced polyester (FRP) shall be in accordance with ASTM D3841, Type II, Grade 1, Class 124, as indicated.

2.14 ACRYLIC SHEET

Acrylic sheet shall be in accordance with the flammability requirements of ASTM E84 and shall conform to ANSI Z97.1.

2.15 POLYCARBONATE SHEET

Polycarbonate sheet shall conform to SAE AMS3611.

2.16 ANCHORS AND FASTENERS

Exposed anchor and fastener materials shall be compatible with metal to which applied and shall match in color and finish and shall be non-rusting, non-corroding, and non-staining. Exposed fasteners shall be tamper-proof.

2.17 SHOP FABRICATION AND MANUFACTURE

2.17.1 Factory Workmanship

Work shall be assembled in the shop, as far as practical, ready for installation at the site. Work that cannot be shop assembled shall be given a trial fit in the shop to ensure proper field assembly. Holes for bolts and screws shall be drilled or punched. Drilling and punching shall produce clean, true lines and surfaces. Welding to or on structural steel shall be in accordance with AWS D1.1/D1.1M. Welding shall be continuous along the entire area of contact. Exposed welds shall be ground smooth. Exposed surfaces of work shall have a smooth finish and exposed riveting shall be flush. Fastenings shall be concealed where practical. Items specified to be galvanized shall be by hot-dip process after fabrication if practical. Galvanization shall be in accordance with ASTM A123/A123M and ASTM A653/A653M, as applicable. Other metallic coatings of steel sheet shall be in accordance with ASTM A924/A924M. Joints exposed to the weather shall be formed to exclude water. Drainage and weep holes shall be included as required to prevent condensation buildup.

2.17.2 Dissimilar Materials

Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood, or absorptive materials subject to wetting, the surfaces shall be protected with a coat of asphalt varnish or a coat of zinc-molybdate primer to prevent galvanic or corrosive action.

2.17.3 Shop Painting

Surfaces of miscellaneous metal work, except nonferrous metal, corrosion resisting steel, and zinc-coated work, shall be given one coat of zinc-molybdate primer or an approved rust-resisting treatment and metallic primer in accordance with manufacturer's standard practice. Surfaces of items to be embedded in concrete shall not be painted. Upon completion of work, damaged surfaces shall be recoated.

2.18 COLOR, FINISH, AND CONTRAST

Color shall be as indicated on the drawings or selected from manufacturers standard colors. Color listed is not intended to limit the selection of equal colors from other manufacturers. For buildings required to be handicapped-accessible, the characters and background of signs shall be eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background - either light characters on a dark background or dark characters on a light background.

2.19 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated above paragraph under the contractor's quality control approval. These materials should be certified and listed Korean Industrial Standards (KS) as a minimum and may subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Signs, plaques, or dimensional letters shall be installed in accordance with approved manufacturer's instructions at locations shown on the approved detail drawings; submit drawings showing elevations of each type of sign; dimensions, details, and methods of mounting or anchoring; shape and thickness of materials; and details of construction. A schedule showing the location, each sign type, and message shall be included. Circuits installed underground shall conform to the requirements of Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Steel conduits installed underground and illuminated signage mounted directly on buildings shall be in conformance with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Signs shall be installed plumb and true at mounting heights indicated, and by method shown or specified. Signs mounted on other surfaces shall not be installed until finishes on such surfaces have been completed. Submit manufacturer's installation instructions and cleaning instructions.

3.1.1 Anchorage

Anchorage and fastener materials shall be in accordance with approved manufacturer's instructions for the indicated substrate. Anchorage not otherwise specified or indicated shall include slotted inserts, expansion shields, and powder-driven fasteners when approved for concrete; toggle bolts and through bolts for masonry; machine carriage bolts for steel; lag bolts and screws for wood.

3.1.2 Protection and Cleaning

The work shall be protected against damage during construction. Hardware and electrical equipment shall be adjusted for proper operation. Glass, frames, and other sign surfaces shall be cleaned in accordance with manufacturer's instructions. After signs are completed and inspected, Cover all project identification, directional, and other signs which may mislead the public. Covering shall be maintained until instructed to be removed by the Contracting Officer or until the facility is to be opened for business. Submit six copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions shall include simplified diagrams for the equipment as installed. Signs shall be cleaned, as required, at time of cover removal.

3.2 FIELD PAINTED FINISH

Miscellaneous metals and frames shall be field painted in accordance with Section 09 90 00 PAINTS AND COATINGS. Anodized metals, masonry, and glass shall be protected from paint. Finish shall be free of scratches or other blemishes.

-- End of Section --

SECTION 10 14 02

INTERIOR SIGNAGE
02/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes
AA PK-1	(2009) Pink Sheets: Designations and Chemical Composition Limits for Aluminum Alloys in the Form of Castings & Ingot

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 2604	(2005) Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1	(2009; Errata 2010) Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

AMERICAN WELDING SOCIETY (AWS)

AWS D1.2/D1.2M	(2008) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM C1036	(2010; E 2012) Standard Specification for

	Flat Glass
ASTM D635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191	Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines

1.2 SYSTEM DESCRIPTION

Submit detail drawings showing elevations of each type of sign, dimensions, details and methods of mounting or anchoring, mounting height, shape and thickness of materials, and details of construction. A schedule showing the location, each sign type, and message shall be included. Signs shall be complete with lettering, framing as detailed, and related components for a complete installation. Signage shall be obtained from a single manufacturer with edges and corners of finished letterforms and graphics true and clean.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Installation; G

SD-10 Operation and Maintenance Data

Operating Instructions; G

1.4 DELIVERY, STORAGE, AND HANDLING

Materials shall be packaged to prevent damage and deterioration during shipment, handling, storage and installation. Product shall be delivered to the jobsite in manufacturer's original packaging and stored in a clean, dry area in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Signs, plaques, and dimensional letters shall be the standard product of a manufacturer regularly engaged in the manufacture of such products that essentially duplicate signs that have been in satisfactory use at least 2 years prior to bid opening.

2.2 ROOM IDENTIFICATION/DIRECTIONAL SIGNAGE SYSTEM

2.2.1 Standard Room Signs

Signs shall consist of acrylic plastic 2 mm (0.080 inch) thickness minimum conforming to ANSI Z97.1, laminated thermosetting Type MP plastic (three-ply melamine plastic laminate with phenolic core), or 6063-T5 extruded aluminum in accordance with ASTM B221M (ASTM B221) and ASTM B209M (ASTM B209) and shall conform to the following:

a. Frames shall be molded acrylic, 6 mm (1/4 inch) wide, unless otherwise indicated on contract drawings.

b. End caps shall be molded acrylic with round or square style corners, unless otherwise indicated on contract drawings.

c. Units shall be frameless. Corners of signs shall be squared or rounded to 13 mm (1/2 inch) radius.

2.2.2 Changeable Message Strip Signs

Changeable message strip signs shall be of same construction as standard room signs to include a clear sleeve that will accept a paper or plastic insert identifying changeable text. The insert shall be prepared die-cut vinyl letters applied to 0.38 mm (0.015 inch) rigid vinyl film, dry transfer letters applied to paper card stock, typeset message photographically enlarged to size and mounted on paper card stock, or typewritten message photographically enlarged or used at actual size.

2.2.3 Type of Mounting For Signs

Provide extruded aluminum brackets for hanging, projecting, and double-sided signs. Mounting for framed, hanging, and projecting signs shall be by mechanical fasteners. Surface mounted signs shall be mounted with 1.6 mm (1/16 inch) thick vinyl foam tape, countersunk mounting holes in plaques and mounting screws, or magnetic tape, as indicated, fabricated from materials that are not corrosive to sign material and mounting surface.

2.2.4 Graphics

Signage graphics for modular signs shall conform to one of the following, and be as indicated on contract drawings:

a. Subsurface copy: Copy is transferred to the back face of clear acrylic sheeting forming the panel face to produce precisely formed opaque image. This method bonds all sign elements (color, graphics, lettering, braille and substrate) into a single unit.

b. Silk-screened First Surface Copy (non-tactile): Message shall be applied to panel using the silkscreen process. Silk-screened images shall be executed with photo screens prepared from original art. Hand cut screens will not be accepted. Original art is defined as artwork that is a first generation reproduction of the specified art. Edges and corners shall be clean.

c. Surface Applied Photopolymer: Integral graphics and braille achieved by photomechanical stratification processes. Photopolymer used for ADA compliant graphics shall be of the type that has a minimum durometer reading of 90. Tactile graphics shall be raised 0.8 mm (1/32 inch) from the first surface of plaque by photomechanical stratification process.

d. Engraved Copy: Machine engrave letters, numbers, symbols, and other graphics into panel sign on face to produce precisely formed copy and sharp images, incised to uniform depth. Melamine plastic engraving stock used for ADA compliant graphic shall be three-ply lamination contrasting color core meeting ASTM D635.

e. Graphic Blast Raised Copy: Background is sandblasted to a uniform depth of 0.8 mm (1/32 inch) leaving raised text and Braille. Background shall be painted with polyurethane paint.

f. Embossed: Methods other than sandblasting such as vacuum formed to create ADA compliant projected graphics.

g. Cast, fabricated, or solid aluminum Letters: 6 mm (1/4 inch) thick shall be provided and fastened to the message panel with concealed fasteners.

2.2.5 Character Proportions and Heights

Letters and numbers on signs conform to 36 CFR 1191.

2.2.6 Raised and Braille Characters and Pictorial Symbol Signs (Pictograms)

Raised letters and numbers on signs shall conform to 36 CFR 1191.

2.3 BUILDING DIRECTORIES

Building directories shall be lobby directories or floor directories, and shall be provided with a changeable directory listing consisting of the areas, offices and personnel located within the facility. Dimensions, details, and materials of sign and message content shall be as shown on the drawings.

2.3.1 Header Panel

Header panel shall have background metal to match frame and shall have raised letters, be acrylic with raised acrylic letters, or be ES/MP plastic with raised letters.

2.3.2 Doors

2.3.2.1 Door Glazing

Door glazing shall be in accordance with ASTM C1036, Type 1, Class 1, Quality 3, minimum 3 mm (1/8 inch) thick, clear acrylic sheet 4.8 mm (3/16 inch) thick, or clear polycarbonate sheet 4.8 mm (3/16 inch) thick.

2.3.2.2 Door Construction

Extruded aluminum door frame shall be of same finish as surrounding frame. Corners shall be mitered, reinforced, welded, and assembled with concealed fasteners. Hinges shall be standard with the manufacturer, in finish to match frames and trim. Glazing shall be set in frame with resilient glazing channels.

2.3.2.3 Door Locks

Door locks shall be manufacturer's standard, and shall be keyed alike. Provide two sets of keys.

2.3.3 Fabrication

Extruded aluminum frames and trim shall be assembled with corners reinforced, welded and mitered to a hairline fit, with no exposed fasteners.

2.3.4 Illuminated Units

Illuminated directory units shall have concealed internal top or back lighting with rapid start fluorescent tube lamp, internal wiring, and lead at wire for connection. Electrical work shall comply with NFPA 70 and shall be UL or FM listed.

2.3.5 Negative Graphics Directory System

Directory shall consist of internally illuminated unit with backlit photo negative directory strips and a black background. Unit shall have a tinted tempered safety solar glass door. Design of unit shall be as shown.

2.3.5.1 Construction

The directory shall be constructed of an aluminum 150 mm (6 inch) deep frame with satin black or dark bronze anodized finish. Unit shall be semi or fully recessed, or pedestal mounted. Unit shall have a 75 mm (3 inch) high header lettering as shown. Unit shall have a 9.3 mm (3/8 inch) face door frame with concealed hinges and locking system. Door frame shall be aluminum with satin finish, unless otherwise indicated on contract drawings.

2.3.5.2 Message Strips

Message strips shall be photo negative type updatable by user. Message strips shall be as shown on the drawings.

2.3.6 Changeable Letter/Message Strip Directory System

Directory shall consist of a non-illuminated unit with , cast vinyl to receive molded changeable letter tilesunless otherwise indicated on contract drawings. Design of unit shall be as shown in the drawings.

2.3.6.1 Construction

The directory shall be constructed of an aluminum 50 mm (2 inch) deep frame with satin black or dark bronze anodized finish. Unit shall be surface mounted, semi or fully recessed, or pedestal mounted, as indicated. Unit shall have a 75 mm (3 inch) high header with lettering as shown. Unit shall have a 9.3 mm (3/8 inch) face concealed hinge door and locking system, lift off frame with tempered safety glass or fixed frameas indicated. Door frame shall be aluminum with satin finish, unless otherwise indicated on contract drawings.

2.3.6.2 Message Strips

Name strips shall be updatable by user. Name strips shall be acrylic sized in accordance with manufacturer's standard. Tabbed vinyl letters and numbers shall be provided in accordance with the drawings.

2.3.7 Touch Screen Electronic Directory System

Touch screen electronic directory system shall be a complete turnkey system consisting of touch screen monitor, processor, update terminal with software connected through a telephone network or local area network (LAN). The system shall be in compliance with the layout and number shown. Electrical equipment shall be UL listed and shall comply with NFPA 70. Unit shall be free-standing or wall mounted.

2.3.7.1 Directory Unit

Directory unit shall consist of 1 (one) 400 mm (16 inch) touch screen monitor and membrane keypad with alphanumeric 38 keys. Screen resolution shall be SVGA 1280 x 1024. Monitor shall be full color. Processor shall be Intel i3 or better with sound peripherals and have a listing capacity of 1,000,000 items. Directory unit shall be of design and finishes as shown.

2.3.7.2 Update Terminal

Update terminal unit shall consist of a 350 mm (14 inch) color monitor with 101 key keypad. Unit shall have a 132 column report printer. Unit shall include a Intel I3 or better PC processor with floppy disk from update terminal to each directory. System shall include network from update to each directory and network from mainframe to update terminal to each directory. Communications shall be over a telephone network or a LAN.

2.4 METAL PLAQUES

2.4.1 Cast Metal Plaques

2.4.1.1 Fabrication

Cast metal plaques shall have the logo, emblem and artwork cast in the bas relief or flat relief technique. Plaques shall be fabricated from prime aluminum, bronze, or yellow brass.

2.4.1.2 Border

Border shall be flat band, plain edge, bevel, or custom ornamental.

2.4.1.3 Background

Background texture shall be leather or fine pebble.

2.4.1.4 Mounting

Mounting shall be concealed, rosettes and anchors, rosettes and toggle bolts, or invisible.

2.4.1.5 Finish

Finishes shall consist of one of the following:

Aluminum light colored sandblasted background. Letters shall be satin polished and entire plaque shall be sprayed with two coats of clear lacquer.

Aluminum with background sprayed dark gunmetal colored lacquer. Letters shall be satin polished and entire plaque sprayed with two coats clear lacquer.

Bronze with dark finish oxidized background. Letters shall be satin polished and entire plaque sprayed with two coats of clear lacquer.

Aluminum or bronze with background sprayed with standard color. Letters shall be satin polished.

2.4.2 Chemically Etched Metal Plaques

2.4.2.1 Fabrication

Plaque shall be chemically single or double etched one-piece brass, bronze, zinc, or magnesium 3.175 mm (0.125 inch) thick.

2.4.2.2 Finish

Single-etched raised areas shall be in gold-tone, silver-tone, or bronze-tone finish and recessed areas shall be color-filled. Double-etched raised areas shall be gold-tone or silver-tone and recessed textured areas shall be gold-tone or silver-tone color-filled.

2.4.3 Frost and Surface Oxidized Plaques

2.4.3.1 Fabrication

Plaque shall be frosted and surface oxidized one-piece anodized aluminum, brass, bronze, or stainless steel 3.175 mm (0.125 inch) thick.

2.4.3.2 Finish

Material finish shall be satin or polished. Frosted areas shall be oxidized black for aluminum or stainless steel or black or brown, for brass or bronze.

2.5 DIMENSIONAL BUILDING LETTERS

2.5.1 Fabrication

Letters shall be fabricated from cast aluminum or cast bronze 2.29 mm (0.090 inch) aluminum sheet, extruded aluminum, or injection molded plastic. Letters shall be cleaned by chemical etching or cleaned ultrasonically in a special degreasing bath. Letters shall be packaged for protection until installation.

2.5.2 Typeface

Typeface shall be helvetica medium.

2.5.3 Size

Letter size shall be as indicated.

2.5.4 Finish

Anodized aluminum finish shall be provided, unless otherwise indicated.

2.5.5 Mounting

Threaded studs or steel U-bracket, cap screws, and expansion bolts of number and size recommended by manufacturer, shall be supplied for concealed anchorage. Letters which project from the mounting surface shall have stud spacer sleeves. Letters, studs, and sleeves shall be of the same material. Templates for mounting shall be supplied.

2.6 PRESSURE SENSITIVE LETTERS

Ensure that edges and corners of finished letterforms and graphics are true and clean. Do not use letterforms and graphics with rounded positive or negative corners, nicked, cut, or ragged edges.

2.6.1 Typeface

Helvetica medium.

2.6.2 Size

As indicated.

2.7 ALUMINUM ALLOY PRODUCTS

Aluminum extrusions shall be at least 3 mm (1/8 inch) thick, and aluminum plate or sheet shall be at least 1.3 mm (0.0508 inch) thick. Extrusions shall conform to ASTM B221M (ASTM B221); plate and sheet shall conform to ASTM B209M (ASTM B209). Where anodic coatings are specified, alloy shall conform to AA PK-1 alloy designation 514.0. Exposed anodized aluminum finishes shall be as shown. Welding for aluminum products shall conform to AWS D1.2/D1.2M.

2.8 ANODIC COATING

Anodized finish shall conform to AA DAF45 as follows:

a. Clear (natural) designation AA-M10-C22-A31, Architectural Class II 0.010 mm (0.4 mil) or thicker.

b. Integral color anodized designation AA-M10-C22-A32, Architectural Class 0.010 to 0.018 mm (0.4 to 0.7 mil).

c. Electrolytically deposited color-anodized designation AA-M10-C22-A34, Architectural Class II 0.010 to 0.018 mm (0.4 to 0.7 mil).

2.9 ORGANIC COATING

Organic coating shall conform to AAMA 2604, with total dry film thickness not less than 0.030 mm (1.2 mils).

2.10 FABRICATION AND MANUFACTURE

2.10.1 Factory Workmanship

Holes for bolts and screws shall be drilled or punched. Drilling and punching shall produce clean, true lines and surfaces. Exposed surfaces of work shall have a smooth finish and exposed riveting shall be flush. Fastenings shall be concealed where practicable.

2.10.2 Dissimilar Materials

Where dissimilar metals are in contact, the surfaces will be protected to prevent galvanic or corrosive action.

2.11 COLOR, FINISH, AND CONTRAST

Color shall be as indicated on the drawings. Finish of all signs shall be eggshell, matte, or other non-glare finish as required in handicapped-accessible buildings.

2.12 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Signs shall be installed plumb and true and in accordance with approved manufacturer's instructions at locations shown on the detail drawings. Submit one hard copy & one digital copy (.pdf - text searchable) of operating instructions outlining the step-by-step procedures required for system operation. The instructions shall include simplified diagrams for the system as installed, the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Each set shall be permanently bound and shall have a hard cover. The following identification shall be inscribed on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS", name and location of the facility, name of the Contractor, and contract number. Mounting height and mounting location shall conform to 36 CFR 1191. Required blocking shall be installed. Signs on doors or other surfaces shall not be installed until finishes on such surfaces have been installed. Signs installed on glass surfaces shall be installed with matching blank back-up plates in accordance with manufacturer's instructions and requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, package 1. Illuminated signage shall be in conformance with the requirements of Section 26 51 00 INTERIOR LIGHTING.

3.1.1 Anchorage

Anchorage shall be in accordance with approved manufacturer's instructions. Anchorage not otherwise specified or shown shall include slotted inserts, expansion shields, and powder-driven fasteners when approved for concrete; toggle bolts and through bolts for masonry; machine carriage bolts for steel; lag bolts and screws for wood. Exposed anchor and fastener materials shall be compatible with metal to which applied and shall have matching color and finish. Where recommended by signage manufacturer, foam tape pads may be used for anchorage. Foam tape pads shall be minimum 2 mm (1/16 inch) thick closed cell vinyl foam with adhesive backing. Adhesive shall be transparent, long aging, high tech formulation on two sides of the vinyl foam. Adhesive surfaces shall be protected with a 0.13 mm (5 mil) green flat stock treated with silicone. Foam pads shall be sized for the signage in accordance with signage manufacturer's recommendations. Signs mounted to painted gypsum board surfaces shall be removable for painting maintenance. Signs mounted to lay-in ceiling grids shall be mounted with clip connections to ceiling tees.

3.1.2 Protection and Cleaning

Protect the work against damage during construction. Hardware and electrical equipment shall be adjusted for proper operation. Glass, frames, and other sign surfaces shall be cleaned at completion of sign installation in accordance with the manufacturer's approved instructions and the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, Package 1. Submit six copies of maintenance instructions listing routine procedures, repairs, and guides.

-- End of Section --

SECTION 10 21 13

TOILET COMPARTMENTS
01/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A336/A336M	(2010a) Standard Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts
ASTM A385/A385M	(2011) Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B36/B36M	(2008a) Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
ASTM B456	(2011; E 2011) Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium

ASTM B86	(2011) Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloy Foundry and Die Castings
ASTM D6386	(2010) Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2009) Accessible and Usable Buildings and Facilities

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS2460	(2007) Plating, Chromium

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60003	(Basic) Partitions, Toilet, Complete

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191	Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines

1.2 SYSTEM DESCRIPTION

Provide a complete and usable toilet partition system, including toilet enclosures, room entrance screens, urinal screens, system of panels, hardware, and support components. Furnish the partition system from a single manufacturer, with a standard product as shown in the most recent catalog data.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Hardware and Fittings
Warranty

1.4 REGULATORY REQUIREMENTS

Conform to ICC A117.1 code for access for the handicapped operation of toilet compartment door and hardware.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the manufacturer's original unopened packages with the brand, item identification, and project reference clearly marked. Store components in a dry location that is adequately ventilated; free from dust, water, other contaminants, and damage during delivery, storage, and construction.

1.6 WARRANTY

Provide certification or warranties that metal toilet partitions will be free of defects in materials, fabrication, finish, and installation and will remain so for a period of not less than 5 years after completion.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Galvanized Steel Sheet

Provide galvanized steel sheet cold-rolled, stretcher-level, commercial quality material, conforming to ASTM A653/A653M. Conform surface preparation of material for painting to ASTM D6386, Method A.

2.1.2 Sound-Deadening Cores

Provide sound deadening consisting of treated kraft paper honeycomb cores with a cell size of not more than 25 mm (1 inch). Resin-material content shall weigh not less than 11 percent of the finished core weight. Expanded cores shall be faced on both sides with kraft paper.

2.1.3 Anchoring Devices and Fasteners

Provide steel anchoring devices and fasteners hot-dipped galvanized after fabrication, in conformance with ASTM A385/A385M and ASTM A123/A123M. Conceal all galvanized anchoring devices.

2.1.4 Brackets

Wall brackets shall be two-ear panel brackets, T-style, 25 mm (1-inch) stock. Provide stirrup style panel-to-pilaster brackets.

2.1.5 Hardware and Fittings

2.1.5.1 General Requirements

Conform hardware for the toilet partition system to CID A-A-60003 for the specified type and style of partitions. Provide hardware finish highly resistant to alkalis, urine, and other common toilet room acids. Comply latching devices and hinges for handicap compartments with 36 CFR 1191; provide chrome-plated steel or stainless steel devices and hinges with door latches that operate without either tight grasping or twisting of the wrist of the operator. Submit three samples of each item, including anchoring devices and fasteners. Approved hardware samples may be installed in the work if properly identified.

a. Conform cold-rolled sheet steel to ASTM A336/A336M, commercial quality.

b. Zinc-base alloy shall conform to ASTM B86, Alloy AC41-A.

c. Brass shall conform to ASTM B36/B36M, Alloy C26800.

d. Aluminum shall conform to ASTM B221M (ASTM B221).

e. Corrosion-resistant steel shall conform to ASTM A167, Type 302 or 304.

2.1.5.2 Finishes

a. Chrome plating shall conform to ASTM B456.

b. Finish shall conform to SAE AMS2460, Class I, Type I or II.

c. Aluminum shall have a clear anodic coating conforming to AA DAF45.

d. Corrosion-resistant steel shall have a No. 4 finish.

e. Exposed fasteners shall match the hardware and fittings.

2.1.6 Door Hardware

2.1.6.1 Hinges

Hinges shall be adjustable to hold in-swinging doors open at any angle up to 90 degrees and outswinging doors to 10 degrees. Provide self-lubricating hinges with the indicated swing. Hinges shall be the surface-mounted or cutout-insert type and have one of the following type of return movements:

a. Gravity return movement

b. Spring-action cam return movement

c. Torsion-rod return movement

2.1.6.2 Latch and Pull

Latch and pull shall be a combination rubber-faced door strike and keeper equipped with emergency access.

2.1.6.3 Coat Hooks

Coat hooks shall be combination units with hooks and rubber tipped pins.

2.2 PARTITION PANELS AND DOORS

Fabricate partition panels and doors not less than 25 mm (1 inch) thick with face sheets not less than 1.006 mm (0.0396 inch) thick.

2.2.1 Toilet Enclosures

Conform toilet enclosures to CID A-A-60003, Type I, Style A, floor supported, B, ceiling hung, C, overhead braced, or F, overhead braced-alcove as indicated. Furnish width, length, and height of toilet enclosures as shown. Provide a width of 25 mm (1 inch). Finish surface of panels shall be painted metal, Finish 1, laminated plastic, Finish 3, solid phenolic, Finish 4, or solid polyethylene, Finish 5; water resistant; graffiti resistant; non-absorbent; with plastic face sheets permanently fused to plastic core; 6 mm (1/4 inch) radius beveled edges.

Reinforce panels indicated to receive toilet paper holders or grab bars for mounting of the items required. Provide grab bars to withstand a bending stress, shear stress, shear force, and a tensile force induced by 1112 N (250 lbf). Grab bars shall not rotate within their fittings.

2.2.2 Room Entrance Screens

Conform room entrance screens to CID A-A-60003, Type II, Style A, floor anchored, B, ceiling hung braced, C, overhead braced, or D, wall hung. Finish surface of screens shall be painted metal, Finish 1, laminated plastic, Finish 3, solid phenolic, Finish 4, or solid polyethylene, Finish; water resistant; graffiti resistant; non-absorbent; with plastic face sheets permanently fused to plastic core; 6 mm (1/4 inch) radius beveled edges. Furnish length and height of screens as shown. Provide thickness of 25 mm (1 inch). Fabricate screens from the same types of panels, pilasters, and fittings as the toilet partitions.

2.2.3 Urinal Screens

Conform urinal screens to CID A-A-60003, Type III, Style A, floor supported, B, ceiling hung, C, overhead braced, D, floor to ceiling hung, or E, floor to ceiling post supported. Provide finish for surface of screens as painted metal, Finish 1, laminated plastic, Finish 3, solid phenolic, Finish 4, or solid polyethylene, Finish 5; water resistant; graffiti resistant; non-absorbent; with plastic face sheets permanently fused to plastic core; 6 mm (1/4 inch) radius beveled edges. This item may contain post-consumer or post-industrial recycled content. Furnish width and height of urinal screens as shown. Provide thickness of 25 mm (1 inch). Secure wall hung urinal screens with a minimum of three wall stirrup brackets. 1050 mm (42 inch) long, continuous flanges. Fabricate screens from the same types of panels and pilasters as the toilet partitions. Use corrosion-resistant steel fittings and fasteners.

2.3 CEILING-HUNG PARTITIONS

Pilasters shall be not less than 31.75 mm (1-1/4 inch) thick with face sheets not less than 1.613 mm (0.0635 inch) thick. Anchoring device at the top of the pilaster shall be welded to the reinforced face sheets and shall have not less than two 9.525 mm (3/8 inch) round threaded rods, lock washers, and leveling-adjustment nuts. Anchoring device shall be designed to transmit the strain and loading on the pilaster directly to the structural support above without putting strain or loading on the finished ceiling. Trim piece at the top of the pilaster shall be 76.2 mm (3 inch) high and fabricated from not less than 0.762 mm (0.030 inch) thick stainless steel.

2.4 FLOOR-ANCHORED PARTITIONS

Pilasters shall be not less than 31.75 mm (1-1/4 inch) thick with face sheets not less than 1.613 mm (0.0635 inch) thick. Provide anchoring device at the bottom of the pilaster consisting of a steel bar not less than 12.7 by 22.2 mm (1/2 by 7/8 inch) welded to the reinforced face sheets and having not less than two 9.5 mm (3/8 inch) round anchorage devices for securing to the floor slab. Provide anchorage devices complete with threaded rods, expansion shields, lock washers, and leveling-adjustment nuts. Trim piece at the floor shall be 76.2 mm (3 inch) high and fabricated from not less than 0.76 mm (0.030 inch) thick corrosion-resistant steel.

2.5 OVERHEAD-BRACED PARTITIONS

Pilasters shall be not less than 31.75 mm (1-1/4 inch) thick with face sheets not less than 1.0 mm (0.0393 inch) thick. Provide anchoring device at the bottom of the pilaster consisting of a channel-shaped floor stirrup fabricated from not less than 1.6 mm (0.0635 inch) thick material and a leveling bolt. Secure the stirrup to the pilaster with not less than a 4.76 mm (3/16 inch) bolt and nut after the pilaster is leveled. Secure the stirrup to the floor with not less than two lead expansion shields and sheetmetal screws. Fabricate overhead brace from a continuous extruded aluminum tube not less than 25.4 mm (1 inch) wide by 38.1 mm (1-1/2 inch) high, 3.2 mm (0.125-inch) wall thickness. Finish shall be AA-C22A31 in accordance with AA DAF45. Set and secure brace into the top of each pilaster. Fabricate 76.2 mm (3 inch) high trim piece at the floor from not less than 0.76 mm (0.030 inch) thick corrosion-resistant steel.

2.6 PILASTER SHOES

Provide shoes at pilasters to conceal floor-mounted anchorage. Pilaster shoes shall be aluminum, stainless steel, or one piece molded HDPE. Height shall be 76 mm (3 inches).

2.7 HARDWARE

Hardware for the toilet partition system shall conform to CID A-A-60003 for the specified type and style of partitions. Hardware shall be pre-drilled by manufacturer if required. Hardware finish shall be highly resistant to alkalis, urine, and other common toilet room acids. Hardware shall include: chrome plated non ferrous cast pivot hinges, gravity type, adjustable for door close positioning; nylon bearings; black anodized aluminum door latch; door strike and keeper with rubber bumper; and cast alloy chrome plated coat hook and bumper. Latching devices and hinges for handicap compartments shall comply with 36 CFR 1191 and shall be chrome-plated steel or stainless steel door latches that operate without either tight grasping or twisting of the wrist of the operator. Screws and bolts shall be stainless steel, tamper proof type. Wall mounting brackets shall be continuous, full height, aluminum or stainless steel, in accordance with toilet compartment manufacturer's instructions. Floor-mounted anchorage shall consist of corrosion-resistant anchoring assemblies with threaded rods, lock washers, and leveling adjustment nuts at pilasters for structural connection to floor.

2.8 COLORS AND FINISHES

2.8.1 Colors

Provide manufacturer's standard color charts for color of finishes for toilet partition system components. Color of pilaster shoes shall match the core of solid plastic compartments and screens.

2.8.2 Finishes No. 1 Through No. 3

Conform partitions, panels, screen, and door finishes to CID A-A-60003 finished with Finish No. 1, baked enamel, Finish No. 2, stainless steel, or Finish No. 3, laminated plastic.

2.8.3 Finishes No.4 and No. 5

Provide solid plastic fabricated of solid phenolic core with melamine facing sheets or polymer resins (polyethylene) formed under high pressure rendering a single component section not less than 25.4 mm (one inch) thick. Colors shall extend throughout the panel thickness. Provide exposed finish surfaces: smooth, waterproof, non-absorbent, and resistant to staining and marking with pens, pencils, or other writing devices. Solid plastic partitions shall not show any sign of deterioration when immersed in the following chemicals and maintained at a temperature of 27 degrees C (80 degrees F) for a minimum of 30 days:

Acetic Acid (80 percent)	Hydrochloric Acid (40 percent)
Acetone	Hydrogen Peroxide (30 percent)
Ammonia (liquid)	Isopropyl Alcohol
Ammonia Phosphate	Lactic Acid (25 percent)
Bleach (12 percent)	Lime Sulfur
Borax	Nicotine
Brine	Potassium Bromide
Caustic Soda	Soaps
Chlorine Water	Sodium Bicarbonate
Citric Acid	Trisodium Phosphate
Copper Chloride	Urea; Urine
Core Oils	Vinegar

2.9 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 PREPARATION

Take field measurements prior to the preparation of drawing and fabrication to ensure proper fits. Verify that field measurements, surfaces, substrates and conditions are as required, and ready to receive work. Verify correct spacing of plumbing fixtures. Verify correct location of built in framing, anchorage, and bracing. Report in writing to Contracting Officer prevailing conditions that will adversely affect satisfactory execution of the work of this section. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 METAL PARTITION FABRICATION

a. Fabricate metal Partition Panels, doors, screens, and pilasters required for the project from galvanized-steel face sheets with formed edges. Face sheets shall be pressure-laminated to the sound-deadening core with edges sealed with a continuous locking strip and corners mitered and welded. Ground all welds smooth. Provide concealed reinforcement for installation of hardware, fittings, and accessories. Surface of face sheets shall be smooth and free from wave, warp, or buckle.

b. Before application of an enamel coating system, solvent-clean galvanized-steel surfaces to remove processing compounds, oils, and other contaminants harmful to coating-system adhesion. After cleaning,coat the surfaces with a metal-pretreatment phosphate coating. After pretreatment, finish exposed galvanized-steel surfaces with a baked-enamel coating system as specified.

c. Provide an enamel coating system consisting of a factory-applied baked acrylic enamel coating system. Coating system shall be a durable, washable, stain-resistant, mar-resistant finish.

3.3 INSTALLATION

Install partitions rigid, straight, plumb, and level, with the panels centered between the fixtures. Provide a panel clearance of not more than 13 mm (1/2 inch) and secure the panels to walls and pilasters with not less than two wall brackets attached near the top and bottom of the panel. Locate wall brackets so that holes for wall bolts occur in masonry or tile joints. Secure Panels to pilasters with brackets matching the wall brackets. Provide for adjustment due to minor floor variations. Locate head rail joints at pilaster center lines. Install adjacent components for consistency of line and plane. Equip each door with hinges, one door latch, and one coat hook and bumper. Align hardware to uniform clearance at vertical edges of doors.

a. Secure panels to hollow plastered walls with toggle bolts using not less than M6x1 (1/4-20) screws of the length required for the wall thickness. Toggle bolts shall have a load-carrying strength of not less than 2668.9 N (600 pounds) per anchor.

b. Secure panels to ceramic tile on hollow plastered walls or hollow concrete-masonry walls with toggle bolts using not less than M6x1 (1/4-20) screws of the length required for the wall thickness. Toggle bolts shall have a load-carrying strength of not less than 2668.9 N (600 pounds) per anchor.

c. Secure panels to solid masonry or concrete with lead or brass expansion shields designed for use with not less than M6x1 (1/4-20) screws, with a shield length of not less than 38.1 mm (1-1/2 inch). Expansion shields shall have a load-carrying strength of not less than 2668.9 N (600 pounds) per anchor.

d. Submit Installation Drawings for metal toilet partitions and urinal screens showing plans, elevations, details of construction, hardware, reinforcing and blocking, fittings, mountings and escutcheons. Indicate on drawings the type of partition, location, mounting height, cutouts, and reinforcement required for toilet-room accessories.

3.4 CEILING-HUNG PARTITIONS

Secure pilasters to the structural support above with the anchorage device specified. Make all leveling devices readily accessible for leveling, plumbing, and tightening the installation. Level the bottoms of doors with bottoms of pilasters when doors are in a closed position.

3.5 FLOOR-ANCHORED PARTITIONS

Secure pilasters to the floor with the anchorage device specified. Make all leveling devices readily accessible for leveling, plumbing, and tightening the installation. Level tops of doors with tops of pilasters when doors are in a closed position. Expansion shields shall have a minimum 50.8 mm (2-inch) penetration into the concrete slab.

3.6 OVERHEAD-BRACED PARTITIONS

Secure pilasters to the floor with the anchorage device specified. Make all leveling devices readily accessible for leveling, plumbing, and tightening the installation. Secure overhead brace to the pilaster face with not less than two fasteners per face. Expansion shields shall have a minimum 50.8 mm (2-inch) penetration into the concrete slab. Make tops of doors parallel with the overhead brace when doors are in a closed position.

3.7 FINAL ADJUSTMENT

After completion of the installation, make final adjustments to the pilaster-leveling devices, door hardware, and other working parts of the partition assembly. Doors shall have a uniform vertical edge clearance of approximately 5 mm (3/16 inch) and shall rest open at approximately 30 degrees when unlatched.

3.8 CLEANING

Baked enamel finish shall be touched up with the same color of paint that was used for the finish. Clean all surfaces of the work, and adjacent surfaces soiled as a result of the work, in an approved manner compliant with the manufacturer's recommended cleaning and protection from damage procedures until accepted. Remove all equipment, tools, surplus materials, and work debris from the site.

-- End of Section --

SECTION 10 26 13

WALL AND CORNER GUARDS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM D256	(2010) Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D543	(2006) Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM D635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G21	(2013) Determining Resistance of Synthetic Polymeric Materials to Fungi

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM AMP 500	(2006) Metal Finishes Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(2013) Standard for Fire Doors and Other Opening Protectives

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	Scientific Certification Systems (SCS)Indoor Advantage

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1545	(2005) Instrumental Color Difference Measurement for Exterior Finishes, Textiles and Colored Trim

UL ENVIRONMENT (ULE)

ULE Greenguard	UL Greenguard Certification Program

1.2 SUSTAINABILITY REQUIREMENTS

Materials in this technical specification may contribute towards contract compliance with sustainability requirements. See Section 01 33 29 LEED DOCUMENTATION for project local/regional materials, low-emitting materials, recycled content, certified wood and rapidly renewable materials requirements

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Corner Guards
Wall Guards (Bumper Guards)
Door Protectors
Wall Covering/Panels

SD-03 Product Data

Corner Guards
Wall Guards (Bumper Guards)
Door Protectors
Wall Covering/Panels

SD-04 Samples

Finish

SD-06 Test Reports

Corner Guards
Wall Guards (Bumper Guards)
Door Protectors
Wall Covering/Panels

SD-07 Certificates

Corner Guards

Wall Guards (Bumper Guards)
Door Protectors
Wall Covering/Panels

SD-11 Closeout Submittals

LEED Documentation

1.4 SUSTAINABLE DESIGN CERTIFICATION

Product shall be third party certified in accordance with ULE Greenguard Gold, SCS Scientific Certification Systems Indoor Advantage Gold or equal. Certification shall be performed annually and shall be current.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the project site in manufacturer's original unopened containers with seals unbroken and labels and trademarks intact. Keep materials dry, protected from weather and damage, and stored under cover. Materials shall be stored at approximately 21 degrees C (70 degrees F) for at least 48 hours prior to installation.

1.6 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

To the maximum extent possible, corner guards, door and door frame protectors, wall guards (bumper guards), wall panels and wall covering shall be the standard products of a single manufacturer and shall be furnished as detailed. Drawings show general configuration of products required, and items differing in minor details from those shown will be acceptable.

2.1.1 Resilient Material

Provide resilient material consisting of high impact resistant extruded acrylic vinyl, polyvinyl chloride, or injection molded thermal plastic conforming to the following:

2.1.1.1 Minimum Impact Resistance

Minimum impact resistance shall be 960.8 N-m/m (18 ft-lbs/sq. inch) when tested in accordance with ASTM D256, (Izod impact, ft-lbs per sq inch notched).

2.1.1.2 Fire Rating

Fire rating shall be Class I when tested in accordance with ASTM E84, having a maximum flame spread of 25 and a smoke developed rating of 450 or less. Material shall be rated self extinguishing when tested in accordance with ASTM D635. Material shall be labeled and tested by an approved nationally known testing laboratory. Resilient material used for protection on fire rated doors and frames shall be listed by the testing laboratory performing the tests. Resilient material installed on fire rated wood/steel door and frame assemblies shall have been tested on similar type assemblies. Test results of material tested on any other combination of door/frame assembly will not be acceptable.

2.1.1.3 Integral Color

Colored components shall have integral color and shall be matched in accordance with SAE J1545 to within plus or minus 1.0 on the CIE-LCH scales.

2.1.1.4 Chemical and Stain Resistance

Materials shall be resistant to chemicals and stains reagents in accordance with ASTM D543.

2.1.1.5 Fungal and Bacterial Resistance

Materials shall be resistant to fungi and bacteria in accordance with ASTM G21, as applicable.

2.2 CORNER GUARDS

2.2.1 Resilient Corner Guards

Corner guard units shall be flush mounted or surface mounted type, radius formed to profile shown. Corner guards shall extend from floor to ceiling. Mounting hardware, cushions, and base plates shall be furnished. Assembly shall consist of a snap-on corner guard formed from high impact resistant resilient material, mounted on a continuous aluminum retainer. Extruded aluminum retainer shall conform to ASTM B221, alloy 6063, temper T5 or T6. Flush mounted type guards shall act as a stop for adjacent wall finish material. Factory fabricated end closure caps shall be furnished for top and bottom of surface mounted corner guards. Flush mounted corner guards installed in fire rated wall shall maintain the rating of the wall. Insulating materials that are an integral part of the corner guard system shall be provided by the manufacturer of the corner guard system. Exposed metal portions of fire rated assemblies shall have a paintable surface.

2.2.2 Stainless Steel Corner Guards

Stainless steel corner guards shall be fabricated of 1.3 mm (16 gauge), 0.9 mm (18 gauge) thick material conforming to ASTM A167, type 302 or 304. Corner guards shall extend from floor to ceiling. Corner guard shall be formed to dimensions shown.

2.3 WALL GUARDS (BUMPER GUARDS)

2.3.1 Wall Guards, Combination Handrail/Wall Guards and Handrails

Wall guards, combination handrail/wall guards, and handrails shall be provided with prefabricated end closure caps, inside and outside corners, concealed splices, cushions, mounting hardware and other accessories standard with the manufacturer. Extruded aluminum retainers shall conform to ASTM B221, alloy 6063, temper T5 or T6. End caps and corners shall be field adjustable to assure close alignment with handrails and wall guards. Wall guards, Combination handrail/wall guards shall have profile as shown with vinyl carpet inserts.

2.3.2 Wall Guards/Bed Locators

Wall guards shall consist of snap-on covers of high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick, mounted over 50 mm (2 inch) wide aluminum, minimum 1.57 mm (0.062 inch) thick retainer, anchored to wall at maximum 600 mm (24 inch) on center.

2.3.3 Combination Handrail/Wall Guards

Combination handrail/wall guards shall consist of snap-on covers of high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick, on a continuous, extruded aluminum retainer, minimum 1.83 mm (0.072 inch) thick anchored to wall at maximum 800 mm (32 inch) on center.

2.3.4 Handrails

Handrails shall consist of snap-on covers of high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick on a continuous extruded aluminum retainer, minimum 1.83 mm (0.072 inch) thick anchored to wall at maximum 800 mm (32 inch) on center. Handrails shall be provided with prefabricated end closure caps, inside and outside corners, concealed splices, cushions, mounting hardware and other accessories standard with the manufacturer. End caps and corners shall be field adjustable to assure close alignment with handrails.

2.4 DOOR PROTECTORS

Door, Door envelope, Door knob and door frame protection items shall consist of high impact resistant acrylic vinyl or polyvinyl chloride resilient material, minimum 1.52 mm (0.060 inch) thick for doors and 0.89 mm (0.035 inch) thick for door frames. Coordinate door and door frame protection material requirements with door and frame suppliers to insure fit for all components and color matching with other resilient materials. Provide adhesive as recommended by resilient material manufacturer.

2.5 WALL COVERING/PANELS

Provide wall covering/panels consisting of high impact rigid acrylic vinyl or polyvinyl chloride resilient material. Panel sizes shall be 0.61 x 1.22 m (2 x 4 ft) . Submit fire rating and extinguishing test results for resilient material. Also submit statements attesting that the items comply with specified fire and safety code requirements.

2.5.1 Rigid Vinyl Acrylic Wall Covering

Wall covering thickness shall be 0.56, 0.71, 1.02, 1.52 mm (0.022, 0.028, 0.040, 0.375 inch).

2.5.2 High Impact Wall Panels

Wall panel face and edge thickness shall be 0.56, 0.71 mm (0.022, 0.028 inch). Panel face shall be factory banded to a 9.53 mm (0.375 inch) thick fiberboard core. The backside of the panel shall be laminated with a moisture resistant vapor barrier.

2.6 TRIM, FASTENERS AND ANCHORS

Provide vinyl trim, fasteners and anchors for each specific installation as shown.

2.7 FINISH

Submit three samples indicating color and texture of materials requiring color and finish.

2.7.1 Aluminum Finish

Finish for aluminum shall be in accordance with AA DAF45. Exposed aluminum shall be designation AA-C22A31 chemically etched medium matte, with clear anodic coating AA-C22A32 chemically etched medium matte with integrally colored anodic coating class II architectural coating 0.010 mm (0.4 mil) thick. Concealed aluminum shall be mill finish as fabricated, uniform in natural color and free from surface blemishes.

2.7.2 Stainless Steel Finish

Finish for stainless steel shall be in accordance with ASTM A167 Type 302 or 304, NAAMM AMP 500, finish number 4.

2.7.3 Resilient Material Finish

Finish for resilient material shall be embossed velour stipple fake wood-grain high gloss vinyltexture with colors in accordance with SAE J1545.

2.8 ADHESIVES

Adhesive for resilient material shall be in accordance with manufacturers recommendations.

2.9 COLOR

Color shall be as indicated. Color listed is not intended to limit the selection of equal colors from other manufacturers.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Corner Guards and Wall Guards (Bumper Guards)

Material shall be mounted at location indicated in accordance with manufacturer's recommendations.

3.1.2 Door, Door Frame Protectors, and Wall Panels

Surfaces to receive protection shall be clean, smooth, and free of obstructions. Protectors shall be installed after frames are in place, but prior to hanging of doors, in accordance with manufacturer's specific instructions. Adhesives shall be applied in controlled environment in accordance with manufacturer's recommendations. Protection for fire doors and frames shall be installed in accordance with NFPA 80.

3.1.3 Stainless Steel Guards

a. Mount guards on external corners of interior walls, partitions and columns as shown in accordance with manufacturer's recommendations.

b. Where corner guards are installed on walls, partitions or columns finished with plaster or ceramic tile, anchor corner guards as indicated, provide continuous 1.5 mm (16 gage) thick, perforated, galvanized z-shape steel anchors welded to back edges of corner guards and wired to metal studs expansion bolted to concrete or masonry with four 10 mm (3/8 inch) diameter bolts, spaced 400 mm (16 inch) on centers. Coat back surfaces of corner guards, where shown, with a non-flammable, sound deadening material. Corner guards shall overlap finish plaster surfaces.

c. Where corner guards are installed on exposed structural glazed facing tile units or masonry wall, partitions or columns, anchor corner guards as indicated, anchor corner guards to existing walls with 6 mm (1/4 inch) oval head stainless steel countersunk expansion or toggle bolts, anchor corner guards with four nominal 1.3 mm (0.0516 inch) thick, adjustable galvanized steel anchors, spaced as shown. Grout spaces solid between guards and backing with portland cement and sand mortar.

d. Where corner guards are installed on gypsum board, clean surfaces and anchor guards with a neoprene solvent-type contact adhesive specifically manufactured for use on gypsum board construction. Remove excess adhesive from the guard edges and allow to cure undisturbed for 24 hours.

e. For wall guards, space brackets at no more than 900 mm (3 feet) on centers and anchor to the wall in accordance with the manufacturer's installation instructions.

-- End of Section --

SECTION 10 28 13

TOILET ACCESSORIES
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C1036	(2010; E 2012) Standard Specification for Flat Glass

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4528	(2003) Paper Holder
KS F 4529	(1998) Towel Hanger
KS L 2406	(2001) Mirror

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Accessory Items; G

SD-10 Operation and Maintenance Data

Electric Hand Dryer; G

1.3 DELIVERY, STORAGE, AND HANDLING

Wrap toilet accessories for shipment and storage, then deliver to the jobsite in manufacturer's original packaging, and store in a clean, dry area protected from construction damage and vandalism.

1.4 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

Provide toilet accessories where indicated in accordance with paragraph SCHEDULE. Porcelain type, tile-wall accessories are specified in Section 09 30 00 CERAMIC TILE QUARRY TILE, AND PAVER TILE. Provide each accessory item complete with the necessary mounting plates of sturdy construction with corrosion resistant surface.

2.1.1 Anchors and Fasteners

Provide anchors and fasteners capable of developing a restraining force commensurate with the strength of the accessory to be mounted and suited for use with the supporting construction. Provide tamperproof design or oval heads exposed fasteners with finish to match the accessory.

2.1.2 Finishes

Except where noted otherwise, provide the following finishes on metal:

Metal	Finish
Stainless steel	No. 4 satin finish
Carbon steel, copper alloy, and brass	Chromium plated, bright

2.2 ACCESSORY ITEMS

Conform to the requirements for accessory items specified below. Submit fasteners proposed for use for each type of wall construction, mounting, operation, and cleaning instructions and one sample of each other accessory proposed for use. Incorporate approved samples into the finished work, provided they are identified and their locations noted. Submit certificate for each type of accessory specified, attesting that the items meet the specified requirements.

2.2.1 Facial Tissue Dispenser (FTD)

Provide surface or recessed mounted facial tissue dispenser, Type 304 stainless steel face, satin finish, or bright polished finish. Secure face of recessed dispenser by friction with suitable spring steel clips. Provide a minimum capacity of 200 two-ply tissues for dispenser.

2.2.2 Grab Bar (GB)

Provide an 18 gauge, 32 mm (1-1/4 inch) grab bar OD Type 304 stainless steel. Provide form and length for grab bar as indicated. Provide concealed or exposed mounting flange. Provide grab with satin finish or peened non-slip surface. Furnish installed bars capable of withstanding a 2.225 kN (500 pound) vertical load without coming loose from the fastenings and without obvious permanent deformation. Allow 38 mm (1-1/2 inch) space between wall and grab bar.

2.2.3 Medicine Cabinet (MC)

Construct medicine cabinet with cold-rolled carbon steel sheet of minimum

0.76 mm (0.03 inch) thickness, formed from a single sheet of steel or mechanically formed and spot welded. Provide width, height and depth of cabinet in accordance with paragraph SCHEDULE.

2.2.3.1 Sliding Door Cabinet, Class 1

Provide surface mounted vanity or recessed cabinet sliding door cabinet assembly with design and lighting arrangement as indicated. Provide a minimum of 2 shelves per cabinet. Provide a narrow frame mirror.

2.2.3.2 Swinging Door Cabinet, Class 2

Furnish swinging door cabinet assembly, including the lighting arrangement, as indicated. Provide surface or recess mounted assembly. Locate cabinet centrally behind the door with a minimum of two shelves. Provide stainless steel or carbon steel door hinges. Provide permanent type magnets used in door catches. Provide doors with a mirror.

2.2.4 Mirrors, Glass (MG)

Provide Type I transparent flat type, Class 1-clear glass for mirrors. Glazing Quality q1 6 mm (1/4 inch) thick conforming to ASTM C1036 or KS L 2406. Coat glass on one surface with silver coating, copper protective coating, and mirror backing paint. Provide highly adhesive pure silver coating of a thickness which provides reflectivity of 83 percent or more of incident light when viewed through 6 mm (1/4 inch) thick glass, free of pinholes or other defects. Provide copper protective coating with pure bright reflective copper, homogeneous without sludge, pinholes or other defects, of proper thickness to prevent "adhesion pull" by mirror backing paint. Provide mirror backing paint with two coats of special scratch and abrasion-resistant paint and baked in uniform thickness to provide a protection for silver and copper coatings which will permit normal cutting and edge fabrication.

2.2.5 Mirror, Metal (MM)

Provide a brightly polished stainless steel metal mirror of 0.94 mm (0.037 inch) minimum thickness, edges turned back 6 mm (1/4 inch) and recess fitted with tempered hardboard backing, and theft-proof fasteners. Provide size in accordance with paragraph SCHEDULE.

2.2.6 Mirror, Tilt (MT)

Provide surface mounted tilt mirror with full visibility for persons in a wheelchair. Furnish adjustable or fixed tilt mirror, extending at least 100 mm (4 inch) from the wall at the top and tapering to 25 mm (1 inch) at the bottom. Provide size in accordance with the drawings. Conform to ASTM C1036 and paragraph Glass Mirrors.

2.2.7 Paper Towel Dispenser (PTD)

KS F 4528. Provide paper towel dispenser constructed of a minimum 0.7 mm (0.03 inch) Type 304 stainless steel, surface or recessed mounted. Provide a towel compartment and a mirror door and liquid soap dispenser for each dispenser. Furnish tumbler key lock or concealed tumbler key lock locking mechanism.

2.2.8 Combination Paper Towel Dispenser/Waste Receptacle (PTDWR)

Provide recessed or semi-recessed dispenser/receptacle with a capacity of 600 sheets of C-fold, single-fold, or quarter-fold towel. Design waste receptacle to be locked in unit and removable for service. Provide tumbler key locking mechanism. Provide waste receptacle capacity of 45 or 68 L (12 or 18 gallons), as indicated. Fabricate a minimum 0.7 mm (0.03 inch) stainless steel welded construction unit with all exposed surfaces having a satin finish. Provide waste receptacle that accepts reusable liner standard for unit manufacturer.

2.2.9 Sanitary Napkin Disposer (SND)

Construct a Type 304 stainless steel sanitary napkin disposal with removable leak-proof receptacle for disposable liners. Provide fifty disposable liners of the type standard with the manufacturer. Retain receptacle in cabinet by tumbler lock. Provide disposer with a door for inserting disposed napkins, recessed, partition mounted, double access, or surface mounted, as indicated.

2.2.10 Sanitary Napkin and Tampon Dispenser (SNTD)

Provide sanitary napkin and tampon dispenser surface mounted or recessed. Dispenser, including door of Type 304 stainless steel that dispense both napkins and tampons with a minimum capacity of 20 each. Hang doors with a full-length corrosion-resistant steel piano hinge and secure with a tumbler lock. Provide keys for coin box different from the door keys.

2.2.11 Shower Curtain (SC)

Provide shower curtain, size to suit conditions. Provide anti-bacterial nylon/vinyl fabric curtain. Furnish color as indicated.

2.2.12 Shower Curtain Rods (SCR)

Provide Type 304 stainless steel shower curtain rods 32 mm (1-1/4 inch) OD by 1.24 mm (0.049 inch) minimum straightor bent as required to meet installation conditions.

2.2.13 Soap Dispenser (SD)

Provide soap dispenser surface mounted, liquid type consisting of a vertical Type 304 stainless steel tank with holding capacity of 1.2 L (40 fluid ounces) with a corrosion-resistant all-purpose valve that dispenses liquid soaps, lotions, detergents and antiseptic soaps.

2.2.14 Soap Holder (SH)

Provide surface mounted or recessed Type 304 stainless steel soap holder. Provide stainless steel separate supports.

2.2.15 Shelf, Metal, Heavy Duty (SMHD)

Furnish a minimum 18 gauge stainless steel heavy duty metal shelf with hemmed edges. Provide shelves over 750 mm (30 inch) with intermediate supports. Provide minimum of 16 gauge supports, welded to the shelf, and spaced no more than 750 mm (30 inch) apart.

2.2.16 Shelf, Metal, Light Duty (SMLD)

Support light duty metal shelf between brackets or on brackets. Purpose of brackets is to prevent lateral movement of the shelf. Furnish 600 mm (24 inch) long shelf, unless otherwise indicated. Provide stainless steel shelf and brackets.

2.2.17 Soap and Grab Bar Combination, Recessed (SGR)

Provide recessed type, Type 304 stainless steel soap and grab bar combination bright polished or satin finish.

2.2.18 Hand Sanitizer Dispenser (HSD)

Provide hand sanitizer dispensers complete with mounting brackets, batteries as recommended by manufacturer, sanitizer solution, and one bottle of refill sanitizer solution for each dispenser installed. Dispenser properties and characteristics:

a. Wall mounted
b. Battery operated
c. Automatic, touchless type that dispenses sanitizer when a hand is placed in proximity of a sensor
d. Integral tray below the dispensing portal to catch wasted sanitizer
e. Operated using standard size batteries such as AA cells

2.2.19 Towel Bar (TB)

Provide stainless steel towel bar with a minimum thickness of 0.38 mm (0.015 inch), conforming to KS F 4529. Provide minimum 19 mm (3/4 inch) diameter bar, or 16 mm (5/8 inch) square. Provide bright polish or satin finish.

2.2.20 Towel Pin (TP)

Provide towel pin with concealed wall fastenings, and a pin integral with or permanently fastened to wall flange with maximum projection of 100 mm (4 inch). Provide bright polish or satin finish.

2.2.21 Toilet Tissue Dispenser (TTD)

Furnish Type II - surface mounted or Type III - recess mounted toilet tissue holder with two rolls of standard tissue mounted horizontally or stacked vertically. Provide stainless steel, satin finish cabinet.

2.2.22 Toilet Tissue Dispenser, Jumbo (TTDJ)

Provide surface mounted toilet tissue dispenser with 2 rolls of jumbo tissue. Fabricate cabinet of Type 304, 18 gauge stainless steel with Type 304, 20 gauge stainless steel door or high-impact plastic body and transparent plastic front cover. Provide cover with key lock.

2.2.23 Toothbrush and Tumbler Holder (TTH)

Provide stainless steel, surface mounted toothbrush and tumbler holder. Furnish holder to hold a minimum of four toothbrushes in a vertical position. Provide 57 plus or minus 3 mm (2-1/4 plus or minus 1/8 inch) in diameter size of hole for securing tumbler.

2.2.24 Waste Receptacle (WR)

Provide Type 304 stainless steel waste receptacle, designed for recessed or surface mounting. Provide reusable liner, of the type standard with the receptacle manufacturer. Provide receptacles with push doors and doors for access to the waste compartment with continuous hinges. Furnish tumbler key lock locking mechanism.

2.2.25 Toilet Seat Cover Dispenser (TSCD)

Provide Type 304 stainless steel with recessed mounted or surface mounted toilet seat cover dispensers. Provide dispenser with a minimum capacity of 500 seat covers.

2.2.26 Toilet Seat Cover/Tissue Dispenser/Waste Receptacle (TSCTDWR)

Provide stainless steel and partition mounted, recessed mounted, or surface mounted toilet seat cover, tissue dispenser, and waste receptacle combination. Provide a minimum of 500 seat covers and 2 standard tissue rolls for each dispenser. Provide a waste receptacle of the reusable liner of type standard with the receptacle manufacturer. Furnish tumbler key lock locking mechanism.

2.2.27 Electric Hand Dryer (EHD)

Provide wall mount and electric hand dryer designed to operate at 110/125 volts, 60 cycle, single phase alternating current with a heating element core rating of a maximum 2100 watts. Provide dryer housing of single piece construction and of white porcelain enamel, chrome plated steel, or baked electrostatically applied epoxy. Submit one hard copy & one digital copy (.pdf - text searchable) of maintenance instructions listing routine maintenance procedures and possible breakdowns. Include repair instructions for simplified wiring and control diagrams and other information necessary for unit maintenance.

2.2.28 Diaper Changing Station (DCS)

Provide recess mount or surface mounted diaper changing station fabricated of high impact plastic with no sharp edges. Provide fold down platform concave to the child's shape, equipped with nylon and hook and loop safety straps and engineered to withstand a minimum static load of 113 kg (250 lb). Provide an integral dispenser for sanitary liners for each unit. Provide pictorial for universal use of safety graphics. Furnish color as indicated.

2.2.29 Folding Shower Seat (FSS)

Folding shower seat shall have a frame constructed of type-304 satin finish stainless steel, 16-gauge, 32 mm (1-1/4 inch) square tubing, and 18-gauge, 25 mm (1 inch) diameter seamless tubing. Seat shall be constructed of one-piece, 13 mm (1/2 inch) thick water-resistant, ivory colored solid phenolic with black edge. Clearance between back of shower seat and wall shall be 38 mm (1-1/2 inches) to comply with ADA Accessibility Guidelines (ADAAG). Seat supports shall not come into contact with the floor. Seat shall be able to lock in upright position when not in use. Seat shall be attached to wall by two 75 mm (3 inch) diameter mounting flanges constructed of type-304, 5 mm (3/16 inch) thick stainless steel with satin finish. Manufacturer's service and parts manual shall be provided to building owner/manager upon completion of project.

2.2.30 Mop and Broom Holder (MH)

Stainless steel with grip jaw cam mechanism securing 4 mop or broom handles, unless otherwise indicated. Also includes hooks and storage shelf.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Provide the same finish for the surfaces of fastening devices exposed after installation as the attached accessory. Provide oval exposed screw heads. Install accessories at the location and height indicated. Protect exposed surfaces of accessories with strippable plastic or by other means until the installation is accepted. After acceptance of accessories, remove and dispose of strippable plastic protection. Coordinate accessory manufacturer's mounting details with other trades as their work progresses. Use sealants for brackets, plates, anchoring devices and similar items in showers (a silicone or polysulfide sealant) as they are set to provide a watertight installation. After installation, thoroughly clean exposed surfaces and restore damaged work to its original condition or replace with new work.

3.1.1 Recessed Accessories

Fasten accessories with wood screws to studs, blocking or rough frame in wood construction. Set anchors in mortar in masonry construction. Fasten to metal studs or framing with sheet metal screws in metal construction.

3.1.2 Surface Mounted Accessories

Mount on concealed back plates, unless specified otherwise. Conceal fasteners on accessories without back plates. Install accessories with sheet metal screws or wood screws in lead-lined braided jute, PTFE or neoprene sleeves, or lead expansion shields, or with toggle bolts or other approved fasteners as required by the construction. Install back plates in the same manner, or provide with lugs or anchors set in mortar, as required by the construction. Fasten accessories mounted on gypsum board and plaster walls without solid backing into the metal or wood studs or to solid wood blocking secured between wood studs, or to metal back plates secured to metal studs.

3.2 CLEANING

Clean material in accordance with manufacturer's recommendations. Do not use alkaline or abrasive agents. Take precautions to avoid scratching or marring exposed surfaces.

3.3 SCHEDULE

Accessories as indicated on contract drawings.

-- End of Section --

SECTION 11 68 13

PLAYGROUND EQUIPMENT
02/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A513	(2008a) Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
ASTM B108/B108M	(2014) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B179	(2011) Standard Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from All Casting Processes
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM D1248	(2012) Standard Specification for

	Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D173/D173M	(2003e1; R 2011) Bitumen-Saturated Cotton Fabrics Used in Roofing and Waterproofing
ASTM D2454	(2008) Determining the Effect of Overbaking on Organic Coatings
ASTM D2794	(1993; R 2010) Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D3359	(2009; E 2010; R 2010) Measuring Adhesion by Tape Test
ASTM D3363	(2005e1; R 2011) Film Hardness by Pencil Test
ASTM D6112	(2010) Compressive and Flexural Creep and Creep-Rupture of Plastic Lumber and Shapes
ASTM D648	(2007) Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
ASTM D822	(2001; R 2006) Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
ASTM F1487	(2011) Playground Equipment for Public Use

CONSUMER PRODUCT SAFETY COMMISSION (CPSC)

CPSC Pub No 325	(1997) Handbook for Public Playground Safety

1.2 DEFINITIONS

1.2.1 Age-Appropriate

A term that describes equipment scale to include platform height, fall height and maximum equipment height, that allows safe and successful use by children of a specific chronological age; mental and physical ability; and anthropometric measurement. Maximum equipment height and complexity will not exceed a child's ability in that age group.

1.2.2 Composite Structure

Also "Composite Play Structure; Linked Structure". Two or more play events attached, directly adjacent or functionally linked, to create one integral unit that provides more than one play activity.

1.2.3 Designated Play Surface

Any elevated surface for standing, walking, sitting, or climbing; or a flat surface a minimum 50 mm (2 inches) wide having up to a maximum 30 degree angle from horizontal. In some play events the platform surface will be the same as the designated play surface. However, the terms should not be interchanged as they do not define the same point of measurement in accordance with ASTM F1487.

1.2.4 Guardrail

A device around an elevated surface that prevents inadvertent falls from the elevated surface.

1.2.5 Maximum Equipment Height

The highest point on the equipment (i.e., roof ridge, top of support pole).

1.2.6 Play Event

A piece of manufactured playground equipment that supports one or more play activities.

1.2.7 Protective Barrier

An enclosing device around an elevated surface that prevents both inadvertent and deliberate attempts to pass through the device.

1.2.8 Protective Surfacing

Material to be used within the use zone that meets the fall attenuation requirements of Section 32 18 16.13 PLAYGROUND PROTECTIVE SURFACING.

1.2.9 Suspended Hazard

Cable, wire, rope or similar devices suspended up to a maximum 2100 mm (7 feet) high between play events; or installed up to a maximum 45 degree angle from the ground to the play event.

1.2.10 Tot

A child under 4 years of age in the pre-toddler and toddler age group.

1.2.11 Use Zone

The area beneath and immediately adjacent to a play structure or equipment that is designated for unrestricted circulation around equipment, and on whose surface it is predicted that a user would land when falling from or exiting the equipment.

1.3 SYSTEM DESCRIPTION

1.3.1 Child Safety

Provide play events that meet the child safety performance requirements described in CPSC Pub No 325 and ASTM F1487. The requirements include the following: Head and neck entrapment; sharp points, edges, and protrusions; entanglement; pinch, crush, and shear points; suspended hazards; play event access and egress points; play event use zone perimeter; and design criteria. Since ASTM F1487 criteria is defined for the minimum user through the maximum user (2 through 12 years of age), the requirements for the infant or pre-toddler age group are not prescribed. This specification and Section 32 18 16.13 PLAYGROUND PROTECTIVE SURFACING establish the requirements for the infant and pre-toddler age groups.

1.3.2 Child Accessibility

The accessibility requirement in accordance with ASTM F1487 includes the following: When the play event use zone consists of a protective surfacing rated as inaccessible, provide at least one accessible route from the use zone perimeter to the play event. When there is more than one of the same play activity provided, only one shall meet accessibility requirements (i.e., one swing seat or one spring rocking play event). When the access and egress points are not the same for a play event, provide an accessible route to both. The accessible route shall access all accessible play events and elements. The protective surfacing performance requirements shall be in accordance with Section 32 18 16.13 PLAYGROUND PROTECTIVE SURFACING.

1.3.3 Age Groups

Play areas are designed to provide challenging play activities by age group. Design playground equipment to be age appropriate for the age group designated to use it. There is no anthropometric or fall attenuation significance to the discrepancy for the school-age age group between paragraph CHILD DEVELOPMENT CENTERS (CDC) and paragraph PLAYGROUND AREAS OTHER THAN CDC as described below. The Army age groups are defined as follows:

1.3.3.1 Child Development Centers (CDC)

The age groups accommodated by the CDC program range from 6 weeks through 8 years of age defined as the following: infant age group (6 weeks through 12 months); pre-toddler age group (12 through 24 months); toddler age group (2 through 3 years of age); pre-school age group (3 through 5 years of age); and school-age age group (5 through 8 years of age).

1.3.3.2 Playground Areas Other Than CDC

The age groups accommodated at these areas range from less than 12 months through 12 years of age defined as the following: infant age group (less than 12 months); pre-toddler age group (12 through 24 months); composite toddler/pre-school age group (2 through 5 years of age); school-age age group (5 through 9 years of age); and pre-teen age group (9 through 12 years of age). A multi-age playground consists of the following age groups: infant, pre-toddler, and composite toddler/pre-school age groups.

1.3.4 Equipment Identification

Identify playground equipment with attached and durable label stating the age-group that the equipment is designed to accommodate. Provide permanent WARNING labels and manufacturer's identification labels, ASTM F1487. Submit a list to include part numbers of furnished play event and equipment materials and components.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Configuration
Shop Drawings
Fall Height
Finished Grade and Underground Utilities

SD-03 Product Data

Equipment
Equipment Identification
Delivery, Storage and Handling
Manufacturer Qualification
Wood
Spare Parts
Materials

SD-04 Samples

Color
Two color charts displaying the colors and finishes.

SD-06 Test Reports

Recycled Plastic
Wood Finishes

SD-07 Certificates

Materials
Manufacturer Qualification
Installer Qualification
Manufacturer's Representative
Wood Treatment
Substitution
Play Event Modification
Child Safety and Accessibility Evaluation

SD-10 Operation and Maintenance Data

Maintenance Instructions
One hard copy & one digital copy (.pdf - text searchable) of the manufacturer's operation and maintenance manuals.

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer Qualification

Play events and equipment similar to those furnished shall have been installed in a minimum 10 sites and been in successful service for a minimum 5 year calendar period. The manufacturer shall provide a Certificate of Insurance AA rated for a minimum one million dollars covering both product and general liability. Submit name of the owner or user; service or preventive maintenance provider; date of the installation; point of contact and telephone number; and address for 10 sites.

1.5.2 Installer Qualification

The installer shall be certified by the manufacturer for training and experience installing the play events and equipment. Submit the installer's company name and address, and training and experience certification.

1.5.3 Manufacturer's Representative

The manufacturer's certified playground safety inspector or the manufacturer's designated certified playground safety representative shall supervise the installation and adjustment of the play events and equipment to verify the installation meets the requirements of the manufacturer, this specification, and paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS. Submit the individual's name, company name and address, and playground safety training certificate.

1.5.4 Technical Representative

1.5.4.1 Child Development Centers (CDC)

The technical representative for outdoor play areas at CDC is the installation Child Development Services (CDS) Coordinator. Base the design of the CDC outdoor play area on the developmental play program for the age groups accommodated at the CDC. The play area is designed to support the CDC program and to provide a stage set for creative play. Developmental activities are selected which promote the intellectual, social, emotional and physical growth of the children. The developmental play program is developed by the MACOM CDS Director, installation CDS Coordinator and CDC Director. They are responsible for the developmental play program and the selection of play events to meet that program.

1.5.4.2 Playground Areas Other Than CDC

The technical representative for outdoor play areas on sites other than Child Development Centers (CDC) shall be the Director of Public Works or designated representative. Base the design of these outdoor play areas on the play program and the age groups to be accommodated as determined by the play area committee.

1.5.5 Prohibited Equipment

Equipment that does not meet the Army's developmental play program requirements and are prohibited on outdoor play areas include the following: chain balance beams; rotating equipment, such as merry-go-rounds, log rolls, whirls and may poles; fulcrum seesaws (teeter totters); spring rocking equipment intended for standing; animal figure swings; rope swings; multiple occupancy swings; swinging exercise and trapeze bars; swinging platforms; tire climbers; swinging dual exercise rings; roller slides; trampolines; swinging gates or doors; and new or used vehicle tires. Also play houses or enclosures made of horizontal posts or bars with space between them; wood components treated with creosote, pentachlorophenol, and tributyl tin oxide; and wood components coated with a finish containing pesticide.

1.5.6 Shop Drawings

When the use zone perimeter and play event configuration conflict with the requirements and paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS, submit scale drawings defining the revised use zone perimeters and play event layout and corrective measures to include the following: Adjustment to the play event with the use zone perimeter; use zone perimeter overlaps; hard surface area and pathway widths; structures; exterior plant material and planters; walls and fences; and bare or painted metal platform and slide bed orientation to the direct sun.

1.6 DELIVERY, STORAGE, AND HANDLING

Submit a delivery schedule and manufacturer's name at least 10 calendar days prior to the first day of delivery. Inspect playground equipment, upon arrival at the job site, for meeting age-appropriate requirements for the age-group that the equipment is designated to accommodate, and specified quality in accordance with paragraphs MATERIALS and CONFIGURATION. Equipment shall be delivered, handled, and stored in accordance with the manufacturer's recommendations. Remove from the job site prohibited or unacceptable equipment. The storage area shall be as designated. Store the materials in a dry, covered area until installed.

1.7 WARRANTY

Furnished play events and equipment shall have a minimum 1 year calendar period warranty.

1.8 MAINTENANCE

Submit one hard copy & one digital copy (.pdf - text searchable) of the manufacturer's operation and maintenance manuals containing the Maintenance Instructions and describing the recommended preventive maintenance, inspection frequency and techniques, periodic adjustments, lubricants, and cleaning requirements. Furnish play event and equipment spare parts provided by the manufacturer.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials which are the standard products of a manufacturer regularly engaged in the manufacture of play event products. Submit results of assembled play event structural integrity tests; vertical load tests; and the maximum number of users that can be on the play event. Prior to the delivery of materials, submit certificates of compliance attesting that materials meet the specified requirements. Certified copies of the material certificates shall include composition and tests to which the material has been subjected.

2.1.1 Metal

Metal components shall have factory-drilled holes and be corrosion resistant. The components shall be free of excess weld and spatter. Metallic materials shall conform to Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS. Components with extra holes not filled by hardware or covered by components shall be rejected.

2.1.1.1 Steel

Steel components shall comply with ASTM A135/A135M, ASTM A500/A500M, or ASTM A513. Minimum tensile strength shall be 310 Mpa (45,000 psi). Minimum yield point shall be 225 Mpa (33,000 psi).

2.1.1.2 Aluminum

Extruded aluminum components shall be type 6061-T6, 6062-T6, or 6063-T6, and shall conform to ASTM B221M (ASTM B221). Minimum tensile strength of extruded aluminum components shall be 270 Mpa (39,000 psi), and the minimum yield shall be 250 Mpa (36,500 psi). Cast aluminum alloy shall conform to ASTM B179, ASTM B26/B26M, and ASTM B108/B108M.

2.1.1.3 Chain

Chain shall be a minimum size 4/0 and shall be corrosion resistant zinc plated. Polyvinyl chloride coating shall be as specified.

2.1.1.4 Rope Cable

Rope cable shall be composed of strands of steel cable with a polypropylene or Dacron synthetic covering that is UV stabilized. Cable ends shall be capped to prevent fraying.

2.1.1.5 Hardware

Hardware shall be corrosion resistant and consist of the following: aluminum, stainless steel, brass, zinc plated steel, zinc-chromate plated steel, or galvanized steel, ASTM A153/A153M. When secured, the hardware shall require a tool to prevent unauthorized loosening and removal.

2.1.1.6 Rails, Loops, and Hand bars

Rails, loops, and hand bars shall consist of corrosion resistant aluminum, powder-coated steel or galvanized steel. Polyvinyl chloride coating, if provided, shall be as specified.

2.1.1.7 Anchors

Anchors shall be in accordance with manufacturer's recommendations.

2.1.2 Wood

Wood components shall be exterior premium grade and free of knots, obtained from managed forests. Wood components shall have factory-drilled holes. Components with extra holes not filled by hardware or covered by other components will be rejected.

2.1.2.1 Wood Treatment

Treat wood components that are not naturally rot and insect resistant, by using standard treatment procedures. Any wood placed up to a maximum 150 mm (6 inches) above, or any portion below the top elevation of the protective surfacing, shall be treated after fabrication. Creosote, pentachlorophenol, and tributyl tin oxide are prohibited according to ASTM F1487. Submit wood treatment chemical content, toxicity level, and life-cycle durability.

2.1.2.2 Plywood

Provide plywood that is a minimum 19 mm (3/4 inch) thick exterior premium grade, and adhered with a waterproof glue that will not separate under conditions of prolonged freezing temperatures, extreme heat, or excessive moisture. Face layers shall be smooth, fine and tightly grained, free of knots, patches, or surface irregularities. Exposed surface shall consist of a material with high paint adhesion and retention characteristics. Edges shall be sanded smooth and eased to a minimum 3 mm (1/8 inch) radius. Fill voids at edges with epoxy prior to sanding.

2.1.3 Plastic Components

2.1.3.1 Panels

Plastic panels shall be molded of ultraviolet (UV) and color stabilized polyethylene or nylon with a minimum 5 mm (3/16 inch) thickness, ASTM F1487. Edges shall be a minimum 5 mm (3/16 inch) radius.

2.1.3.2 Window

Plastic windows shall be flat or molded into a bubble shape, consisting of clear polycarbonate plastic a minimum 5 mm (3/16 inch) thick before forming in accordance with ASTM D1248. Material shall be shatterproof and resistant to crazing, cracking, or fogging.

2.1.4 Recycled Plastic

Construct or manufacture recycled material with a maximum 6 mm (1/4 inch) deflection or creep in any member, ASTM D648 and ASTM D6112. Submit results of individual component and assembled unit structural integrity test; creep tolerance; deflection tolerance; and vertical load test results. The estimated percentage of recovered material content in the material and components. Life-cycle durability.

2.1.4.1 High Density Polyethylene

Mold components of ultraviolet (UV) and color stabilized polyethylene consisting of a minimum 75 percent plastic profile of high-density polyethylene, low-density polyethylene, and polypropylene raw material. The material shall be non-toxic, have no discernible contaminates such as paper, foil, or wood, and contain a maximum 3 percent air voids. The material shall be free of splinters, chips, peels, buckling, and cracks and be resistant to deformation from solar heat gain. Material shall have factory-drilled holes. Components with extra holes not filled by hardware or covered by other components will be rejected. The material shall not be painted.

2.1.4.2 Panel

Panels shall be a minimum 6 mm (1/4 inch) thick; exposed edges shall be smoothed, rounded, and free of burrs and points; and the material shall be shatterproof and resistant to fading, cracking, or fogging.

2.1.4.3 Structural Component

Recycled plastic materials will not be used as load bearing structural members.

2.1.4.4 Recycled Plastic Molded As Lumber

For deck or platform construction, the span of the structural support members shall be a maximum 300 mm (12 inches) on center and recycled plastic decking shall connect to a minimum three joists. Material used for decking shall have a non-slip texture surface. The assembly shall deflect a maximum 1/360 of the span of the frame when exposed to a uniform live load of 585 N/m (40 lbs/ft), ASTM D648. The product shall meet the structural integrity test requirements, ASTM F1487 and ASTM D6112.

2.1.5 Coatings

2.1.5.1 Galvanized

Metal components shall be hot-dipped in zinc after fabrication according to ASTM A123/A123M. Remove tailings and sharp protrusions formed as a result of the hot-dip process; edges shall be burnished.

2.1.5.2 Polyester Powder

Powder-coated surfaces shall receive electrostatic zinc coating prior to painting. Powder coating shall be electrostatically applied and shall be oven cured. Polyester powder shall be in accordance with the following: ASTM D3359 for adhesion; ASTM D173/D173M for flexibility; ASTM D3363 for hardness; ASTM D2794 for impact; ASTM D2454 for overbake resistance; ASTM B117 for salt spray resistance; and ASTM D822 for weatherability.

2.1.5.3 Polyvinyl Chloride (PVC)

Prime PVC coating with a clear acrylic thermosetting solution. The primed parts shall be preheated prior to dipping. The liquid polyvinyl chloride shall be UV stabilized and mold-resistant. The coated parts shall be cured. The coating shall be a minimum 2 mm (0.08 inch) thick within a plus or minus 0.5 mm (0.020 inch) tolerance. The coating shall have an 85 durometer hardness, ASTM D3363. The finish shall be slip-resistant.

2.1.5.4 Concrete

Provide concrete conforming to Section 32 16 13 CONCRETE SIDEWALKS AND CURBS AND GUTTERS.

2.1.5.5 Cast-In Place Concrete

Provide cast-in-place concrete material in conformance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.1.6 Wood Sealants

Exposed wood surfaces shall have factory applied prime coat with a minimum 2 spray coats of two-component polyurethane or approved preservative that meets paragraph WOOD TREATMENT.

2.1.6.1 Paint

Paint shall be factory applied to a minimum of 2 coats. Paint shall comply with Section 09 90 00 PAINTS AND COATINGS. Paint shall be weather resistant, and resist cracking, peeling and fading.

2.1.6.2 Sealants

Seal all applied surfaces from air; sealants containing pesticide are prohibited.

2.1.7 Color

Color shall be provided as indicated. Submit 1 color chart displaying the colors and finishes.

2.2 EQUIPMENT

Submit manufacturer's descriptive data; catalog cuts; references; and the latest edition of ASTM F1487 and CPSC Pub No 325. Manufacturer's specifications, handling and storage requirements, installation procedures, and safety data sheets to include the following: bare or painted metal platform and slide bed orientation from the direct sun; warnings; and child safety performance standards.

2.2.1 Configuration

Provide play event configuration, platform height, fall height, and maximum equipment height as indicated. When the configuration varies from the play event shown, submit scale drawings defining the revised configuration to include the following: equipment layout with the use zone perimeter; designated play surface spot elevations; maximum equipment height spot elevations; platform spot elevations; protective barriers; guardrails; bare or painted metal platform and slide bed orientation; and play events in relationship to the playground layout.

2.2.2 Substitution

Substitutions will not be allowed and play events will not be selected without written approval from the technical representative. Evaluate manufacturer substitutions which increase the play event platform height or maximum equipment height. The increased height requires additional protective surfacing in accordance with paragraph FALL HEIGHT. Submit technical representative's written approval.

2.2.3 Platform Height

Platform height is used to define the age group for age appropriate play events and composite structures. To be age appropriate, the platform height shall meet the finished elevations of the age groups in the following paragraphs. For some play events, platform height and paragraph FALL HEIGHT are the same.

2.2.3.1 Pre-Toddler Age Group

Platforms designed for children 12 through 24 months of age shall have a finished elevation a maximum 900 mm (36 inches) above the finished elevation of the protective surfacing.

2.2.3.2 Toddler Age Group

Platforms designed for children 2 through 3 years of age shall have a finished elevation a maximum 1200 mm (48 inches) above the finished elevation of the protective surfacing.

2.2.3.3 Pre-School Age Group

Platforms designed for children 3 through 5 years of age shall have a finished elevation a maximum 1200 mm (48 inches) above the finished elevation of the protective surfacing.

2.2.3.4 School-Age Age Group

Platforms designed for children 5 through 8 years of age shall have a finished elevation a maximum 1800 mm (72 inches) above the finished elevation of the protective surfacing.

2.2.3.5 Pre-Teen Age Group

Platforms designed for children 8 through 12 years of age shall have a finished elevation a maximum 1800 mm (72 inches) above the finished elevation of the protective surfacing.

2.2.4 Protective Barrier and Guardrail

Provide protective barriers and guardrails in accordance with paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS. This specification establishes the protective barrier and guardrail requirements for the infant and pre-toddler age group.

2.2.4.1 Protective Barrier

The protective barrier for pre-toddler, toddler, and pre-school age groups shall be provided on elevated surfaces a minimum 760 mm (30 inches) above the protective surfacing. The protective barrier for school-age and pre-teen age groups shall be provided on elevated surfaces a minimum 1200 mm (48 inches) above the protective surfacing. The protective barrier shall completely surround the elevated surface except for the access or egress route. As infants are not to be placed on an elevated surface, the protective barrier for the infant age group shall be the same as the crawl wall defined in paragraph MEASURING FALL HEIGHT.

2.2.4.2 Guardrail

The guardrail for pre-toddler, toddler, and pre-school age groups shall be provided on elevated surfaces a minimum 510 mm (20 inches) above the protective surfacing. The guardrail for school-age and pre-teen age groups shall be provided on elevated surfaces a minimum 760 mm (30 inches) above the protective surfacing. The guardrail shall completely surround the elevated surface except for the access or egress route. As infants are not to be placed on an elevated surface, the guardrail for the infant age group shall be the same as the crawl wall defined in paragraph MEASURING FALL HEIGHT.

2.2.5 Sand Table

The sand table with a cover shall be as shown. The cover shall not be attached to the table. The sand sieve size shall be provided as defined in Section 32 18 16.13 PLAYGROUND PROTECTIVE SURFACING.

2.2.6 Multiple-Axis (Rotating) Swing

The swivel mechanism shall contain a durable long life bearing to reduce friction and wear. A tire manufactured specifically for a multiple-axis swing shall be provided and shall weigh a maximum of 15.8 kg (35 lbs). The tire shall be composed of rotationally molded, low density elastomer, and internally reinforced with a steel ring. The tire shall have no openings for insects or water. The multiple-axis swing shall not be confused with the multiple occupancy swing as they are not the same.

2.2.7 Single-Axis (To-Fro) Swing

2.2.7.1 General Requirements

The swing seat shall be molded of high quality rubber or polyurethane with an encapsulated steel reinforcement. The swing seat shall be designed to accommodate one user

2.2.7.2 Full Bucket Swing Seat

A full bucket swing seat is designed to accommodate children up to a maximum 4 years of age; the seat is used by a child with adult assistance. The swing seat shall be constructed of rubber with a tempered steel insert molded inside, shall be double-sided, shall be enclosed by rubber both front and back, and shall include a 360 degree waist enclosure and leg enclosures. Leg enclosures shall be sized to avoid head or neck entrapment. Finish shall be smooth and edges shall be rounded. These swing seats shall not be mixed with other swing seats within a bay.

2.2.8 Spring Rocking Equipment

Spring mechanisms shall conform to the requirements for pinch, crush, and shear points for a maximum 54 kg (120 lb) weight limit in accordance with ASTM F1487. Seats shall be designed to accommodate only the intended number of users.

2.2.9 Roofs

Roofs shall contain no designated play surface.

2.2.10 Sliding Poles

Sliding poles shall be a maximum 48 mm (1.9 inch) diameter and a continuous surface with no protruding welds or joints along the sliding area.

2.2.11 Plastic Slide

The slide shall be molded of UV stabilized polyethylene or nylon with minimum of 5 mm (3/16 inch) wall thickness. The edge shall be a minimum 5 mm (3/16 inc)h radius, ASTM D1248, Type II, Class A, Grade G4.

2.2.12 Play House or Enclosures

Provide the play house with a shelf at the window. The play house and enclosures will be designed to provide other than direct outside visibility from a minimum 1.5 m (5 feet) to all inside corners.

PART 3 EXECUTION

3.1 SITE PREPARATION

3.1.1 Finished Grade and Underground Utilities

Submit finished grade, underground utilities, storm-drainage system and irrigation system status; and location of underground utilities and facilities. Verify that finished grades are as indicated; the smooth grading has been completed in accordance with Section 31 00 00 EARTHWORK;

installation of the underground utilities through the area has been completed in accordance with Section 31 00 00 EARTHWORK; installation of the storm-drainage system through the area has been completed in accordance with Section 33 40 00 STORM DRAINAGE; and the installation of underground sprinklers through the area has been completed in accordance with Section 32 84 24 UNDERGROUND SPRINKLER SYSTEMS. The location of underground utilities and facilities in the area of the operation shall be verified. Damage to underground utilities and facilities shall be repaired at the Contractor's expense.

3.1.2 Layout

3.1.2.1 General

The layout of the entire outdoor play area shall be staked before excavation begins to include the following: all play event configuration access and egress points; use zone perimeters; hard surface areas and pathway widths; exterior plant material and planters; walls and fences; and structures. Provide sufficient space between all adjacent play events and individual play events for play activities and circulation. Moving and rotating play events shall be located away from circulation to prevent collisions.

3.1.2.2 Use Zone

The use zone is associated with the following terms; "Clear Area," and "Fall Zone". The use zone shall be free of hard surfaces, objects or obstacles that a child could run into or fall on top of and be injured. The use zone shall consist of protective surfacing in accordance with the requirements of Section 32 18 16.13 PLAYGROUND PROTECTIVE SURFACING. Use zone perimeters shall not overlap hard surfaces. The use zone perimeter shall meet or exceed the requirements of paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS. Use zone perimeters shall not overlap except for certain play events as defined in ASTM F1487.

3.1.3 Orientation

Bare or painted metal platforms and slide beds shall be oriented from the direct sun; or shaded to reduce contact burn risk. Play events that require orientation to adjacent play events or to meet visibility requirements shall be properly oriented.

3.1.4 Obstructions Below Ground

When obstructions below ground affect the work, submit shop drawings showing proposed adjustments for approval.

3.2 INSTALLATION

Play events shall be installed according to the manufacturer's recommendations and as shown to meet the requirements of paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS.

3.2.1 Play Event Modification

Site modifications of play events affect the coverage provided in paragraph WARRANTY; therefore, play events and equipment shall not be modified without the written approval of the manufacturer. Submit manufacturer's written approval.

3.2.2 Wood Finishes

Field applied or touch up of wood finishes shall meet the same specifications as finishes applied at the factory. Submit wood finish chemical content and toxicity level.

3.2.3 Plastic Play Events

Plastic and recycled plastic components shall be connected by stainless steel hardware. The hardware shall be countersunk. Recycled plastic molded as lumber or wood-polymer lumber shall be installed in accordance with the manufacturer's recommendations.

3.2.4 Footings

The top elevation of play event footings will be installed at the subbase of the protective surfacing.

3.2.5 Multiple-Axis (Rotating) Swing

The multiple-axis (rotating) swing shall be located away from other play events and circulation. It shall not be attached to a composite structure.

3.2.6 Single-Axis (To-Fro) Swing

The single-axis (to-fro) swing shall be located on the perimeter of the outdoor play area. It shall not be attached to a composite structure.

3.2.7 Slide

The required exit region clear area shall be provided in accordance with ASTM F1487.

3.2.8 Chain or Rope Ladder, Climber or Net Climber

A chain or rope ladder; climber; net climber; and similar components shall be installed in the vertical position. Angled or arch positions are not accepted.

3.2.9 Composite Structure

The composite structure use zone perimeter shall be composed of the use zone perimeters of the play events that, when joined together, comprise the composite structure.

3.2.10 Fall Height

3.2.10.1 General

The fall height is defined as the vertical distance between the finished elevation of the designated play surface and the finished elevation of the protective surfacing beneath it. For some play events the fall height and paragraph PLATFORM HEIGHT are the same. For some play events the fall height and maximum equipment height are the same. When the furnished play event fall height varies from the play event shown, submit scale drawings defining the revised depth or type of protective surfacing to meet or exceed the requirements of Section 32 18 16.13 PLAYGROUND PROTECTIVE SURFACING shall be provided.

3.2.10.2 Measuring Fall Height

EQUIPMENT	MEASURING FALL HEIGHT
Composite Structure	For a platform surrounded by protective barriers, measure from the platform finished elevation.
	For a platform surrounded by guardrails, measure from the guardrail top elevation.
Infant Crawl Area	A maximum 600 mm (24 inch) height, measured from the crawl wall or barrier finished elevation.
Playhouse, Nonclimbable	Measure from the designated play surface finished elevation.
Spring Rocking Equipment	Measure from the seat top elevation.
Stationary Equipment, Climbable	Measure from the maximum equipment height finished elevation.
Stationary Equipment, Nonclimbable	Measure from the designated play surface finished elevation.
Swing	Measure from the bottom of the pivot point.

3.2.11 Signage

For playground areas other than CDC, durable permanent signage shall be provided to identify the age group the equipment is designed to accommodate. Signage shall be in accordance with Section 10 14 01 EXTERIOR SIGNAGE.

3.3 RESTORATION AND CLEAN UP

When the operation has been completed, clean up and protect the site. Existing areas that have been damaged from the operation shall be restored to original condition at the Contractor's expense.

3.3.1 Clean Up

The site and play events shall be cleaned of all materials associated with the operation. Play events and surfaces shall be cleaned of dirt, stains, filings, and other blemishes occurring from shipment and installation. Cleaning methods and agents shall be as recommended by the manufacturer. Required labeling shall be undamaged and visible in accordance with paragraph EQUIPMENT IDENTIFICATION.

3.3.2 Protection

The area shall be protected as required or directed by providing barricades and signage. Signage shall be in accordance with Section 10 14 01 EXTERIOR SIGNAGE.

3.3.3 Disposal of Materials

Excess and waste material shall be removed and disposed off Government property.

3.4 CHILD SAFETY AND ACCESSIBILITY EVALUATION

a. When the protective surfacing is installed the play events and protective surfacing shall be thoroughly inspected and measured to verify the playground meets manufacturer's recommendations, paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS, and paragraph FALL HEIGHT.

b. The play events shall be age appropriate for the age group using them in accordance with paragraph PLATFORM HEIGHT. Determine 1) secure anchoring; 2) all hardware and connectors are tight; 3) all hardware and connectors require tools to loosen; 4) all hooks are closed; 5) head and neck entrapment; 6) sharp points, edges, and protrusions; 7) entanglement; 8) pinch, crush, and shear points; 9) suspended hazards; 10) all component holes are filled; and 11) recycled plastic components used as load bearing structural members.

c. Use zone distances shall be measured to determine the area is free of hard surfaces, objects or obstacles. Determine exceptions to use zone overlaps occur in accordance with paragraph USE ZONE. Play event fall height shall be measured and compared to critical height value for thickness of installed protective surfacing. The slide exit region shall have the required clear zone. Play events and surfaces shall be properly oriented. Chain, rope, net climbers or similar components shall be installed in a vertical position. Swing seat clearances shall be measured while occupied by a maximum user for the age group using the equipment. Warning labels and manufacturer identification labels shall be visible in accordance with paragraph EQUIPMENT IDENTIFICATION.

d. Play events that do not comply shall be reinstalled. Fasteners, anchors, hardware and labels that do not comply shall be replaced. Ensure positive drainage for the area and the lowest elevation of protective surfacing subgrade has been provided. A written report describing the results of the evaluation shall be provided.

e. Submit records of measurements and findings by the certified playground safety inspector. Submit verification stating that the installed play events and equipment meet manufacturer's recommendations and paragraph CHILD SAFETY AND ACCESSIBILITY STANDARDS.

3.5 RE-INSTALLATION

When re-installation is required, accomplish the following: Re-install the product as specified. Provide new replacement materials supplied by the manufacturer. Material acquisition of replacement parts is the responsibility of the Contractor. Damage caused by the failed installation shall be repaired at the Contractor's expense.

-- End of Section --

SECTION 12 21 00

WINDOW BLINDS
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4517	(2004) Steel and Aluminum Alloy Venetion Blinds

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 701	(2010) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES

SD-03 Product Data

Window Blinds; G

1.3 SYSTEM DESCRIPTION

Provide window treatment, conforming to NFPA 701, complete with necessary brackets, fittings, and hardware. Each window treatment type shall be a complete unit provided in accordance with paragraph WINDOW TREATMENT PLACEMENT SCHEDULE. Mount and operate equipment in accordance with manufacturer's instructions. Windows to receive a treatment shall be completely covered.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver components to the jobsite in the manufacturer's original packaging with the brand or company name, item identification, and project reference clearly marked. Store components in a dry location that is adequately ventilated and free from dust, water, or other contaminants and has easy access for inspection and handling. Store materials flat in a clean dry area with temperature maintained above 10 degrees C (50 degrees F). Do not open containers until needed for installation unless verification inspection is required.

1.5 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period.

PART 2 PRODUCTS

2.1 WINDOW BLINDS

Provide each blind, including hardware, accessory items, mounting brackets and fastenings, as a complete unit produced by one manufacturer. All parts shall be one color, unless otherwise indicated, to match the color of the blind slat. Treat steel features for corrosion resistance. Submit results of Fire Resistance, Flame Spread, and Smoke Contribution tests.

2.1.1 Horizontal Blinds

Provide horizontal blinds with 50 mm (2 inch) or 25 mm (1 inch) slats, conforming to KS F 4517. Blind units shall be capable of nominally 180 degree partial tilting operation and full-height raising. Blinds shall be inside mount, unless otherwise indicated. Provide tapes for 50 mm (2 inch) slats with longitudinal reinforced vinyl plastic in 1-piece turn ladder construction. Tapes for 25 mm (1 inch) slats shall be braided polyester or nylon.

2.1.1.1 Head Channel and Slats

Provide head channel made of steel or aluminum with corrosion-resistant finish nominal 0.46 mm (0.018 inch) for 50 mm (2 inch) or 0.61 mm (0.024 inch) for 25 mm (1 inch) slats. Provide slats of aluminum, not less than 0.203 mm (0.008 inch) thick, and of sufficient strength to prevent sag or bow in the finished blind. Provide a sufficient amount of slats to assure proper control, uniform spacing, and adequate overlap. Enclose all hardware in the head-rail.

2.1.1.2 Controls

The slats shall be tilted by a transparent tilting wand, hung vertically by its own weight, and shall swivel for easy operation. Provide a tilter control of enclosed construction. Provide moving parts and mechanical drive made of compatible materials which do not require lubrication during normal expected life. The tilter shall tilt the slats to any desired angle and hold them at that angle so that any vibration or movement of ladders and slats will not drive the tilter and change the angle of slats. Include a mechanism to prevent over tightening. Provide a wand of sufficient length to reach to within 1500 mm (5 feet) of the floor.

2.1.1.3 Intermediate Brackets

Provide intermediate brackets for installation, as recommended by the manufacturer, of blinds over 1500 mm (60 inch) wide.

2.1.1.4 Bottom Rail

Provide bottom rail made of corrosion-resistant steel with factory applied finish. Provide closed oval shaped bottom rail with double-lock seam for maximum strength. Bottom rail and end caps to match slats in color.

2.1.1.5 Braided Ladders

Provide braided ladders of 100 percent polyester yarn, color to match the slat color. Space ladders 15.2 slats per 300 mm (one foot) of drop in order to provide a uniform overlap of the slats in a closed position.

2.1.1.6 Hold-Down Brackets

Provide universal type hold-down brackets for sill or jamb mount where indicated on placement list.

2.1.1.7 Audio Visual Blinds

In addition to requirements for blinds, each unit shall include light traps at sides, and sill. Provide privacy blinds which provide light enhancing capabilities by means of hidden slat holes. Construct light traps from aluminum or sheet steel, not less than 0.5 mm (0.02 inch) thick, U-shaped, with legs not less than 45 mm (1.75 inch) long for 50 mm (2 inch) blinds or 20 mm (0.75 inches) long for 25 mm (1 inch) blinds. Round or bead edges in contact with blinds. Finish inside surfaces of light traps in a dull gray or black color.

2.1.2 Vertical Blinds

Provide vertical blind units capable of nominal 180 degree partial tilting operation and full stackback. The blinds shall be listed by the manufacturer as designed for heavy duty strength applications including heavy duty hardware. Provide wall mounted, sill-length vertical blinds with outside brackets, unless otherwise indicated on contract drawings. Outside mount type installation shall provide adequate overlap to control light and privacy.

2.1.2.1 Louvers

Provide louvers which are fire resistant solid vinyl, UV stable, and impact resistant and which are flame retardant fabric having straight, flat, unfrayed edges and flat, without noticeable twists. Provide a weight at the bottom of the louver without the insert discoloring the fabric. Louvers that are 90 mm (3-1/2 inch) shall overlap not less than 10 mm (3/8 inch) and 50 mm (2 inch) shall overlap not less than 6 mm (1/4 inch) and be dimensionally stable.

2.1.2.2 Carriers

Provide carriers to support each louver made of molded plastic to transverse on self-fabricated wheels for smooth, easy operation. The hook of the carrier shall have an automatic latch to permit easy installation and removal of the louver, and to securely lock the louver for tilting and traversing.

2.1.2.3 Head-rail System

Provide head-rail system not less than 1.19 mm (0.047 inch) thick and made of anodized aluminum alloy or 0.635 mm (0.027 inch) thick phosphate treated steel with a baked on ivory gloss enamel paint finish. The head-rail shall extend the full width of the blind and be closed with an end cap at each end. One cap shall contain the traversing and tilting controls. The opposite cap will house the pulley for the traversing cord.

2.1.2.4 Valance

Attach the manufacturer's standard valance to the head-rail by metal or plastic holders which grip the top and bottom edge of the valance and accept an insert of the same material as the slats. Provide sufficient clearance behind the valance to permit the louvers to tilt without interference. Extend the head-rail cover the full width of the blind.

2.1.2.5 Controls

Provide tilting and traversing controls that hang compactly at the side of the blinds and reach within 1500 mm (5 feet) of the floor. The tilt/traverse control and bead chain tilting control shall tilt all vanes simultaneously to any desired angle and hold them at that angle. Provide louvers that traverse one way to the right, one way to the left, or two-way split, as indicated. The traversing control cord shall be minimum 1.78 mm (0.070 inch) in diameter with a minimum breaking strength of 556 N (125 pounds). Anchor the cord to a lead carrier linked to all adjacent carriers. Provide louvers that traverse along the head-rail by pulling one side of the looped cord fastened to a cord tension pulley or a fiberglass wand that tilts the louvers by turning the wand and traverses the louvers by using the wand as a control. Sliding glass doors shall have a one way draw with stackback occurring opposite door openings.

2.1.2.6 Connectors and Spacers

The connector shall be flexible, smooth and flat to slide unhindered when carriers move independently of each other, and to nest compactly when carriers are stacking. Relate the length of the links to the louver width in order to equally space the traversing louvers, to maintain uniform and adequate overlap of louvers, and to fully cover the width of the opening.

2.1.2.7 Intermediate Brackets

Provide intermediate installation brackets for blinds over 1575 mm (62 inches) wide.

2.2 COLOR

Provide color, pattern and texture as indicated on the drawings. Color listed is not intended to limit the selection of equal colors from other manufacturers.

2.3 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Submit drawings showing fabrication and installation details. Show layout and locations of track, direction of draw, mounting heights, and details.

3.2.1 Horizontal and Audio Visual Blinds

Perform installation of Horizontal and Audio Visual Blinds in accordance with the approved detail drawings and manufacturer's installation instructions. Install units level, plumb, secure, and at proper height and location relative to window units. Provide and install supplementary or miscellaneous items in total, including clips, brackets, or anchorages incidental to or necessary for a sound, secure, and complete installation. Do not start installation until completion of room painting and finishing operations.

3.2.2 Vertical Blinds and Valance

Perform installation of Vertical Blinds and Valance in accordance with the approved detail drawings and manufacturer's installation instructions. Install units level, plumb, secure, and at proper height and location relative to window units. Provide and install supplementary or miscellaneous items in total, including clips, brackets, or anchorages incidental to or necessary for a sound, secure, and complete installation. Do not start installation until completion of room painting and finishing operations.

3.3 CLEAN-UP

Upon completion of the installation, free window treatments from soiling, damage or blemishes; and adjust them for form and appearance and proper operating condition. Repair or replace damaged units as directed by the Contracting Officer. Isolate metal parts from direct contact with concrete, mortar, or dissimilar metals. Ensure blinds installed in recessed pockets can be removable without disturbing the pocket. The entire blind, when retracted, shall be contained behind the pocket. For blinds installed outside the jambs and mullions, overlap each jamb and mullion 20 mm (0.75 inch) or more when the jamb and mullion sizes permit. Include all hardware, brackets, anchors, fasteners, and accessories necessary for a complete, finished installation.

-- End of Section --

SECTION 12 32 00

MANUFACTURED WOOD CASEWORK
05/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995; R 2004) Basic Hardboard

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E30	(2011) Engineered Wood Construction Guide
APA EWCG	(2005) Engineered Wood Construction Guide: Building Requirements and Related Panel Systems
APA PS 1	(2009) Structural Plywood (with Typical APA Trademarks)

ASME INTERNATIONAL (ASME)

ASME B18.6.1	(1981; R 2008) Wood Screws (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM C1036	(2010; E 2012) Standard Specification for Flat Glass
ASTM D13	(2002) Standard Specification for Spirits of Turpentine

ASTM D4689	(2012) Standard Specification for Adhesive, Casein-Type
ASTM D4690	(2012) Standard Specification for Urea Formaldehyde Resin Adhesives
ASTM F594	(2009; E 2011) Standard Specification for Stainless Steel Nuts
ASTM F836M	(2002; R 2010) Standard Specification for Style 1 Stainless Steel Metric Nuts

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.9	(2010) Cabinet Hardware

COMPOSITE PANEL ASSOCIATION (CPA)

CPA A208.1	(2009) Medium Density Fiberboard (MDF) For Interior Applications
CPA A208.2	(2009) Medium Density Fiberboard (MDF) for Interior Applications

HARDWOOD PLYWOOD AND VENEER ASSOCIATION (HPVA)

HPVA HP-1	(2009) American National Standard for Hardwood and Decorative Plywood

KITCHEN CABINET MANUFACTURERS ASSOCIATION (KCMA)

KCMA A161.1	(2000) Performance & Construction Standards for Kitchen and Vanity Cabinets

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1010	(2009) Set of High Strength Hexagon Bolt, Hexagon Nut and Plain Washers for Friction Grip Joints
KS F 3113	(2004) Plywood for Structure

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA LD 3	(2005) Standard for High-Pressure Decorative Laminates
NEMA LD 3.1	(1995) Performance, Application, Fabrication, and Installation of High-Pressure Decorative Laminates

SCIENTIFIC EQUIPMENT AND FURNITURE ASSOCIATION (SEFA)

SEFA 7	(1996) Recommended Practice for Laboratory and Hospital Service Fittings

U.S. DEPARTMENT OF COMMERCE (DOC)

DOC/NIST PS1	(1995) Construction and Industrial Plywood with Typical APA Trademarks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS FF-B-588	(Rev E; Notice 1) Bolt, Toggle: and Expansion Sleeve, Screw
FS FF-S-325	(Basic; Int Amd 3; Notices 3, 4) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS MM-L-736	(Rev D) Lumber; Hardwood
FS MM-L-751	(Rev H) Lumber; Softwood
FS TT-C-490	(Rev E) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
FS TT-C-520	(Rev B; Notice 1) Coating Compound, Bituminous, Solvent Type, Underbody (for Motor Vehicles)
FS TT-E-489	(Rev J; Notice 2) Enamel, Alkyd, Glass, Low VOC Content
FS TT-E-491	(Rev C; Notice 1) Enamel; Gloss, Synthetic (for Metal and Wood Furniture)
FS TT-F-336	(Rev E; Notice 1) Filler, Wood, Paste
FS TT-V-121	(Rev H; Notice 1) Varnish, Spar, Water-Resisting
FS WW-P-541	(Rev E; Am 1; Notice 1) Plumbing Fixtures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Cabinets
Accessories and Hardware
Countertops
Manufacturer's Standard Color Charts

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver, handle, and store cabinets in a manner that prevents damage or deformity. Provide temporary skids under units as indicated in contract drawings.

1.4 DESIGN

Provide wood cabinets, factory-fabricated and finished in the manufacturer's standard sizes and finishes of the type, design, and configuration indicated. Construct cabinets as specified meeting the requirements of KCMA A161.1. Wall and base cabinet assemblies to consist of individual units joined into continuous sections. Accomplish fastenings to permit removal and replacement of individual units without affecting the remainder of the installation. Provide counters with watertight sink rim when indicated, and removable drawers equipped with position stops to avoid accidental complete withdrawals. Fix or adjust shelves as indicated.

PART 2 PRODUCTS

2.1 GENERAL

Submit Manufacturer's Standard Color Charts for wood and metal cabinets showing the manufacturer's recommended color and finish selections.

Submit Manufacturer's Instructions for wood and metal cabinet systems including special provisions required to install equipment components and system packages. Special notices to detail impedances, hazards and safety precautions.

Provide the manufacturer's cabinets with the standard sizes, type, and design indicated. Provide both wall and base cabinet assemblies to consisting of individual units joined into continuous sections as indicated. Provide fastenings to permit removal and replacement of individual units without affecting the remainder of the installation.

2.2 MATERIALS

Provide steel for cabinet construction conforming to ASTM A1008/A1008M.

Provide Corrosion-Resistant Steel conforming to ASTM A167, Type 302, 304, or 316, Finish 4.

Provide douglas-fir Plywood conforming to APA E30,APA EWCG, and APA PS 1, or KS F 3113 exterior type, fully waterproof bond.

Provide Medium Density Fiberboard (MDF) for interior applications, fully waterproof bond conforming to CPA A208.1 and CPA A208.2.

Provide Glass conforming to ASTM C1036, Type I, Class 1, Quality q3, 6 millimeter (1/4 inch) thick, for unframed sliding glass doors; other glass to conform to ASTM C1036, Type II, Class 1, Quality q8, 5 millimeter (7/32 inch) thick.

Provide Adhesives for application of plastic laminate consisting of a thermosetting urea-resin Type II conforming to ASTM D4690 as recommended by the manufacturer of the laminate. Provide adhesive for wood members conforming to ASTM D4689.

Provide Filler Material conforming to FS TT-F-336.

Provide Hardwood conforming to FS MM-L-736, standard hardwood lumber, S2S.

Provide Hardwood Plywood conforming to HPVA HP-1.

Provide Particle Board conforming to CPA A208.1, Type 1, Grade M or medium density.

Provide Plastic Laminate conforming to ANSI/NEMA LD 3, Style, Type, Grade, Class, and Finish as indicated on contract drawings.

Provide Softwoods conforming to FS MM-L-751, factory and shop grade.

Provide Turpentine conforming to ASTM D13.

Provide Varnish conforming to FS TT-V-121.

Provide Accessories and Hardware conforming to the following requirements, as applicable:

Extension drawer slides: ANSI/BHMA A156.9, Type B85071

Semiconcealed hinges: ANSI/BHMA A156.9, Type B81201, 1-1/2 inches

Full surface hinges: ANSI/BHMA A156.9, Type B81131, 1-1/2 inches

Knob pulls: ANSI/BHMA A156.9, 1-inch diameter, Type B12132

Bar type pulls: ANSI/BHMA A156.9, 4-inch overall length, Type B12012

Semiconcealed hinges: ANSI/BHMA A156.9, Type B81201, 40 millimeter

Full surface hinges: ANSI/BHMA A156.9, Type B81131, 40 millimeter

Knob pulls: ANSI/BHMA A156.9, 25 millimeter diameter, Type B12132

Bar type pulls: ANSI/BHMA A156.9, 100 millimeter overall length, Type B12012

Locks, keying, and keys: As directed

Catches: Magnetic, 22 newton (5-pound) pull

Sliding door set:

Impregnated fiberboard track

Nylon glides

Provide Fasteners conforming to the following:

Screws: ASME B18.6.1, Group, Type and Class as applicable

Anchoring Devices: FS FF-S-325, Group, Type, and Class as applicable

Toggle bolts: FS FF-B-588, Type I, Class A, Style 2

Nuts: ASTM F594, corrosion-resistant steel

Bolts: ASTM A325 or KS B 1010, heavy, hexagon head bolts corrosion-resistant steel

Nuts: ASTM F836M, corrosion-resistant steel

Bolts: ASTM A325M or KS B 1010, heavy, hexagon head bolts corrosion-resistant steel

Corrosion-resistant Steel Sinks:

1.3 millimeter (18-gage) corrosion-resistant steel, integral with corrosion-resistant steel countertop or 1.3 millimeter (18-gage) corrosion-resistant steel, nonintegral, self-rimming

Drain holes in center of bowl

Underside coated with 3 millimeter (1/8-inch) thick sound deadener

Die-form, seamless, raised edges at front and ends

Cove corners to 13 millimeter (1/2-inch) radius

Equip with strainers and tail pieces

Provide sound deadening conforming to FS TT-C-520.

Provide Service Fixtures conforming to the following requirements:

Provide fixtures in accordance with the water conservation policy as stated in the Standard Plumbing Codes, Appendix J.

Faucets: splashback mounted, cast brass, chrome plated, FS WW-P-541

Faucets: deck mounted, cast brass, chrome plated, FS WW-P-541

Gas, air, and vacuum, distilled water, steam, and de-ionized water cocks: cast brass, chrome plated, ground key type

Drains, strainers, and taps: brass, chrome plated, FS WW-P-541

Index buttons: plastic, color codes in accordance with SEFA 7

Special items: provide nipples and locknuts with each fixture as directed.

Metal pretreatment coatings: FS TT-C-490, Type I

Metal pretreatment coatings: FS TT-C-490, Type II

Metal pretreatment coatings: FS TT-C-490, Type III

Enamel: FS TT-E-491, Class 2

2.3 WOOD CABINET FABRICATION

Construct wall and base cabinets with frame fronts and solid ends, or frame construction throughout. Provide 20 by 40 millimeter (3/4-by 1-1/2-inch) kiln-dried hardwood framing members, using mortise and tenon, dovetailed, grove and lapped, biscuit and dado, or doweled, with glue assembly. Brace top and bottom corners with hardwood blocks that are glued with water-resistant glue and nailed in place. Provide base cabinets with an integral toe space at least 65 millimeter (2-1/2 inches) deep and 100 millimeter (4 inches) high. Mount drawers on metal, hardwood, renewable plastic, or fiber guides. Provide fixed or removable and adjustable shelving, as indicated.

Minimum thicknesses of materials for frame-front, solid-end cabinet construction is as follows:

Backs and bottoms of base cabinets and tops of wall cabinets: 3 millimeter (1/8-inch) tempered hardboard. Brace bottoms with wood members glued in place.

Cabinet ends: 15 millimeter (1/2-inch) hardwood-veneer plywood

Doors: 20 millimeter (3/4-inch) hardwood plywood, solid core doors

Drawer fronts: 20 millimeter (3/4-inch) hardwood

Drawer bottoms: 4.76 millimeter (3/16-inch) plywood or tempered hardboard. Drawer bottoms over 380 millimeter (1 foot 3 inches) wide will be braced with wood members glued in place.

Drawer sides and backs: 15 millimeter (1/2-inch) hardwood

Interior partitions or dividers: 15 millimeter (1/2-inch) fir plywood, Grade A-A or hardwood

Shelves: Grade A-B plywood, supported on ends and 600 millimeter (24 inches) on centers

Adjustable shelves: 20 millimeter (3/4-inch) plywood

Base cabinet shelves: 16 millimeter (5/8-inch) plywood

Wall cabinet shelves: 15 millimeter (1/2-inch) plywood or glued-up solid wood, or (1/4-inch) plywood with a solid-wood frame

Minimum thicknesses of materials for frame-type cabinet construction is as follows:

Cabinet ends: 6 millimeter (1/4-inch) hardwood plywood

Backs, bottoms, partitions, and dividers: 4 millimeter (3/16-inch) tempered hardboard in a frame

Provide materials for other components as specified.

2.3.1 High-Pressure Decorative Laminate (HPDL)

ANSI/NEMA LD 3, satin finish, unless otherwise indicated.

2.3.1.1 Countertops

PF 42, satin finish.

2.3.1.2 Vertical Surfaces

GP 28 or PF 30, satin finish.

2.3.1.3 Backing Sheet

BK 20.

2.3.1.4 Cabinet Liner

CL 20.

2.3.2 Hardwood Plywood

HPVA HP-1, Type II (Interior), three- or five-ply, with face veneer of good grade (1) or better. Cover all exposed edges.

2.3.3 Hardwood

Provide hardwood for use in cabinet work, thoroughly seasoned or kiln-dried to 12-15 percent mc; without defects in any exposed parts or surfaces.

2.3.4 Softwood Plywood

DOC/NIST PS1.

2.3.4.1 Countertops

Exterior type, A-C Grade.

2.3.4.2 Elsewhere

Interior type, A-B Grade, may be used in lieu of hardwood plywood where HPDL finish is provided.

2.3.5 Hardboard

AHA A135.4, tempered.

2.3.6 Steel for Cabinets

ASTM A1008/A1008M, cold rolled, commercial quality carbon steel sheet.

2.3.7 Sinks, Lavatories and Fittings

As specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.4 PARTICLE BOARD CABINET FABRICATION

Construct frameless wall and base cabinets with solid particleboard panels throughout, using mortise and tenon, grooved and lapped, with biscuit and dado, or doweled, and glue assembly. Brace top and bottom corners with hardwood blocks that are glued with water-resistant glue and nailed in place. Provide base cabinets with an integral toe space at least 65 millimeter (2-1/2 inches) deep and 100 millimeter (4 inches) high. Mount drawers on metal, hardwood, or renewable plastic or fiber guides. Provide fixed or removable, and adjustable shelving, as indicated on drawings.

Minimum thicknesses of materials for cabinet construction is as follows:

Backs and bottoms of base cabinets and tops of wall cabinets: 16 millimeter (5/8-inch) Grade M-2 or M-2 exterior glue.

Exposed cabinet ends: 16 millimeter (5/8-inch) particle board with a plastic laminate covering

Doors: 20 millimeter (3/4-inch) particle board laminated on all edges

Drawer fronts: 20 millimeter (3/4-inch) particle board laminated on all edges

Drawer bottoms: 3 millimeter (1/8-inch) plywood or tempered hardboard. Brace drawer bottoms over 380 millimeter (1 foot 3 inches) wide with wood members glued in place.

Drawer sides and backs: 15 millimeter (1/2-inch) particle board

Interior partitions or dividers: 15 millimeter (1/2-inch) particle board

Shelves: Supported on ends and 600 millimeter (24 inches) on centers

Adjustable shelves: 20 millimeter (3/4-inch) particle board

Base cabinet shelves: 16 millimeter (5/8-inch) particle board

Wall cabinet shelves: 13 millimeter (1/2-inch) particle board

2.5 PLYWOOD CABINET FABRICATION

Construct frameless wall and base cabinets with solid plywood panels throughout using mortise and tenon, grooved and lapped, with biscuit and dado, or doweled, with glue assembly. Brace top and bottom corners with hardwood blocks that are glued with water-resistant glue and nailed in place. Provide base cabinets with an integral toe space at least 65 millimeter (2-1/2 inches) deep and 100 millimeter (4 inches) high. Mount drawers on metal, hardwood, or renewable plastic or fiber guides. Provide fixed or removable and adjustable shelving, as indicated on drawings.

Minimum thicknesses of materials for cabinet construction is as follows:

Backs and bottoms of base cabinets and tops of wall cabinets: 4 millimeter (3/16-inch) tempered hardboard. Brace bottoms with wood members glued in place.

Cabinet ends: 20 millimeter (3/4-inch) standard veneer-core plywood with a plastic laminate covering

Doors: 20 millimeter (3/4-inch) standard veneer-core plywood laminated on all edges

Drawer fronts: 20 millimeter (3/4-inch) standard veneer-core plywood laminated on all edges

Drawer bottoms: 3 millimeter (1/8-inch) plywood or tempered hardboard. Brace drawer bottoms over 380 millimeter (1 foot 3 inches) wide with wood members glued in place.

Drawer sides and backs: 20 millimeter (3/4-inch) standard veneer-core plywood

Interior partitions or dividers: 20 millimeter (34-inch) standard veneer-core plywood

Shelves: Supported on ends and 600 millimeter v24 inches) on centers

Adjustable shelves: 20 millimeter (3/4-inch) standard veneer-core plywood

Base cabinet shelves: 20 millimeter (3/4-inch) standard veneer-core plywood

Wall cabinet shelves: 20 millimeter (3/4-inch) standard veneer-core plywood

2.6 MELAMINE CABINET FABRICATION

Construct cabinets with frame fronts and solid ends throughout. Frame members will be 20 by 40 millimeter (3/4-by 1-1/2-inch) kiln-dried hardwood, using mortise and tenon, dovetailed or doweled, and glued together. Brace top and bottom corners with hardwood blocks that are glued with water-resistant glue and nailed in place. Provide base cabinets with an integral toe space at least 65 millimeter (2-1/2 inches) deep and 100 millimeter (4 inches) high. Mount drawers on metal, hardwood, or renewable plastic or fiber guides. Provide fixed or removable and adjustable shelving, as indicated on drawings.

Minimum thicknesses of materials for cabinet construction is as follows:

Backs and bottoms of base cabinets and tops of wall cabinets: 4 millimeter (3/16-inch) tempered hardboard. Brace bottoms with wood members glued in place.

Cabinet ends: 20 millimeter (3/4-inch) melamine particle board with a plastic laminate covering

Doors: 20 millimeter (3/4-inch) melamine particle board laminated on all edges

Drawer fronts: 20 millimeter (3/4-inch) melamine particle board laminated on all edges

Drawer bottoms: 3 millimeter (1/8-inch) plywood or tempered hardboard. Brace drawer bottoms over 380 millimeter (1 foot 3 inches) wide with wood members glued in place.

Drawer sides and backs: 16 millimeter (5/8-inch) melamine particle board

Interior partitions or dividers: 16 millimeter (5/8-inch) melamine particle board

Shelves: Supported on ends and 600 millimeter (24 inches) on centers

Adjustable shelves: 20 millimeter (3/4-inch) melamine particle board

Base cabinet shelves: 16 millimeter (5/8-inch) melamine particle board

Wall cabinet shelves: 16 millimeter (5/8-inch) melamine particle board

2.7 LAMINATE CABINET FABRICATION

Construct cabinets with frame fronts and solid ends throughout. Frame members will be 20 by 40 millimeter (3/4-by 1-1/2-inch) kiln-dried hardwood, using mortise and tenon, dovetailed or doweled, and glued together. Brace top and bottom corners with hardwood blocks that are glued with water-resistant glue and nailed in place. Provide base cabinets with an integral toe space at least 65 millimeter (2-1/2 inches) deep and 100 millimeter (4 inches) high. Mount drawers on metal, hardwood, or renewable plastic or fiber guides. Provide fixed or removable and adjustable shelving, as indicated on drawings.

Minimum thicknesses of materials for cabinet construction is as follows:

Backs and bottoms of base cabinets and tops of wall cabinets: 4 millimeter (3/16-inch) tempered hardboard. Brace bottoms with wood members glued in place.

Cabinet ends: 20 millimeter (3/4-inch) standard veneer-core plywood with a plastic laminate covering

Doors: 20 millimeter (3/4-inch) low pressure laminate

Drawer fronts: 20 millimeter (3/4-inch) low pressure laminate

Drawer bottoms: 3 millimeter (1/8-inch) plywood or tempered hardboard. Brace drawer bottoms over 380 millimeter (1 foot 3 inches) wide with wood members glued in place.

Drawer sides and backs: 20 millimeter (3/4-inch) standard veneer-core plywood

Interior partitions or dividers: 20 millimeter (3/4-inch) standard veneer-core plywood

Shelves: Supported on ends and 600 millimeter (24 inches) on centers

Adjustable shelves: 20 millimeter (3/4-inch) standard veneer-core plywood

Base cabinet shelves: 20 millimeter (3/4-inch) standard veneer-core plywood

Wall cabinet shelves: 20 millimeter (3/4-inch) standard veneer-core plywood

2.8 MISCELLANEOUS CABINETS

2.8.1 Combination Sink-and-Base Cabinet

A combination sink-and-base cabinet unit may be furnished in lieu of the base cabinet and inset sink indicated provided the combination unit affords facilities and space equal to those indicated and provided the combination unit matches the adjacent units in materials and construction. Provide a sink with matching drainboards, of corrosion-resistant steel or porcelain-enamel steel, equipped with a chromium-plated swinging-spout faucet with chromium-plated water-control valves or automatic faucet, and chromium-plated cup strainer. Make joints between sink and drainboard and between drainboard and counter top watertight.

2.8.2 Special Purpose Cabinets

Provide special-purpose cabinets, such as cabinets for eye-level oven units, countertop range units, and built-in refrigerators and desks, as indicated on drawings, of the same materials and construction as adjacent cabinets. Provide space adjacent to sink for a dishwasher, as indicated.

2.9 ACCESSORIES AND HARDWARE

Furnish accessories such as utility shelves and racks for extracts, condiments, and towels; bins for sugar and flour; breadboxes; and trays for cutlery and flatware as indicated.

Provide corrosion resistant hardware, and all exposed hardware with a chromium-plated finish or a corrosion-resistant finish as approved. Paint semiconcealed hinges on cabinets where paint finish is required to match the cabinets. Equip doors with bullet-type catches, spring hinges, or magnetic-type catches. Provide door and drawer pulls as indicated.

2.10 CABINETS

The work includes providing new factory-finished kitchen wall and base cabinets with high pressure decorative laminate (HPDL) countertops and bathroom vanity cabinets with HPDL countertops to receive combination lavatory-countertops as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Provide cabinets conforming to KCMA A161.1, requirements specified herein, bearing the "KCMA Certified Cabinet" seal of the Kitchen Cabinet Manufacturers Association, or submit manufacturer's test reports from an approval laboratory that cabinets meet requirements of KCMA A161.1. Provide Countertops conforming to NEMA LD 3.1 and requirements specified herein.

2.10.1 Frame Type Cabinets

Construct the cabinets with frame fronts and solid ends or frame construction throughout. Provide 19 mm (3/4 inch) thick by 38 mm (1-1/2 inch) wide frame members; kiln-dried hardwood, glued together, either mortised and tenoned, dovetailed or doweled, nailed, stapled or screwed. Brace top and bottom corners with either hardwood blocks that are glued together with water resistant glue and nailed in place, or metal or plastic corner braces. Use 3 mm (1/8 inch) thick plywood for backs of cabinets, with tempered hardboard or 9 mm (3/8 inch) thick, 20 kg (44 pound) density particle board. Provide 9 mm (3/8 inch) thick hardwood or 9 mm (3/8 inch) thick, 20 kg (44 pound) density particle board, plywood, melamine, or laminate for backs of cabinets. Provide minimum 9 mm (3/8 inch) thick plywood 20 kg (44 pound) density particle board or good grade or sound grade plywood for bottoms of cabinets, braced with wood members glued in place. Provide cabinet ends made with 16 mm (5/8 inch) thick hardwood plywood, or 16 mm (5/8 inch) thick, 20 kg (44 pound) density particle board core, or 9 mm (3/8 inch) thick, 20 kg (44 pound) density particle board.

2.10.2 Frameless Type Cabinets

The cabinets to be of frameless design and construction. Construct cabinets of minimum 16 mm (5/8 inch) thick, 20 kg (45 pound) density particle board, plywood, melamine or laminate end and floor panels. Construct cabinet back of minimum 5 mm (3/16 inch) thick, 20 kg (45 pound) density particle board, plywood, melamine, or laminate. Dowel and glue hanging rails to end panels, then fastened and hot melt glued to cabinet back. Toe kick plates to be recessed, doweled and glued to the end panels. Brace top and bottom corners with either hardwood blocks glued together with water resistant glue and nailed in place, or fastened with metal or plastic corner braces.

2.11 FINISH

2.11.1 Cabinet Finish

Provide cabinets with a factory-applied durable finish in accordance with KCMA A161.1 requirements and of a type standard with the manufacturer. Fabricate natural finish wood doors, drawer fronts, cabinet fronts, and exposed cabinet sides of wood which will be free of extreme color variations within each panel or between adjacent panels. For exposed exterior surfaces, provide hardwood or grade A-A hardwood veneer with natural stain and sprayed on factory applied finish, melamine plastic finish, or paint-finished wood doors, drawer fronts, cabinet fronts, and exposed cabinet sides fabricated of hardwood or grade C hardwood veneer.

2.11.2 Melamine Laminated Interior Cabinet Finish

Finish plywood, particle board or tempered hardboard cabinet backs with a melamine laminate on the exposed side. Cover particle board shelves on both sides with a laminated melamine finish. Provide Melamine laminate that conforms to the requirements of ANSI/NEMA LD 3 and laminate adhesive that is contact type applied to both surfaces.

2.11.3 Backer Sheets

Provide backer sheets of high pressure plastic laminate, conforming to ANSI/NEMA LD 3, Grade BK20, applied to the underside of all core material.

2.12 COLOR, TEXTURE, AND PATTERN

Provide color as indicated on the drawings. Color listed is not intended to limit the selection of equal colors from other manufacturers.

2.13 LOCAL PRODUCTS

Local materials manufactured in Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as stated in above paragraph under the contractor's quality control approval. These materials should be certified and listed in Korean

Industrial Standards (KS) as a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 FIELD FINISHING OF WOOD CABINETS

For painted finish, apply a prime coat and two coats of synthetic enamel of air-drying quality, conforming to FS TT-E-489, Class A. Provide colors as selected.

For natural finish, use the applicable procedure for the type of wood selected as follows:

For open-grain woods: Apply one coat of paste wood filler, and remove excess filler. Then apply one coat of pale varnish thinned with turpentine, followed by one coat of pale varnish and then by one coat of satin-finish varnish, plus an additional coat of satin-finish varnish on cabinet doors and drawer fronts. Lightly sand surfaces between coats.

For close-grain woods: Apply one coat of pale varnish thinned with turpentine, followed by one coat of pale varnish and then by one coat of satin-finish varnish, plus an additional coat of satin-finish varnish on cabinet doors and drawer fronts. Lightly sand surfaces between coats.

At the Contractor's option, wood cabinets with a factory finish standard set by the cabinet manufacturer may be provided.

3.2 INSTALLATION

Install casework plumb with countertops level to within 1 millimeter in 3000 millimeter (1/16 inch in 10 feet). Level base cabinets by adjusting leveling screws. Scribe and fit scribe strips to irregularities of adjacent surfaces. Gap opening is not to exceed 0.63 millimeter (0.025 inch).

Secure cases permanently to floor and wall construction using 6 millimeter (1/4-inch) diameter masonry anchors, spaced 760 millimeter (30 inches) maximum on center, minimum of two for each case.

Support wall cases on continuous 1.3 millimeter (18-gage) galvanized steel hanging brackets. Secure wall cases in position with screws to blocking. Bolt adjoining cases together. Width of joints not exceed 0.79 millimeter (1/32 inch). Provide closer strips, filler strips, and finish moldings as required. Align doors, adjust hardware, clean and wax surfaces.

Submit Installation Drawings for steel and wood cabinets. Include in drawings location of cabinets, details of cabinets related and dimensional positions, and locations for roughing in plumbing, including sinks, faucets, strainers and cocks.

3.3 CLEANING

On completion of cabinet installation, touch up marred or abraded finished surfaces. Remove crating and packing materials from premises. Wipe down surfaces to remove fingerprints and markings and leave in clean condition.

3.4 INSPECTION

Examine casework grounds and supports for adequate anchorage, foreign material, moisture, and unevenness that could prevent quality casework installation. Ensure that electrical and plumbing rough-ins for casework are complete. Do not proceed with installation until defects are corrected.

-- End of Section --

SECTION 12 36 00

COUNTERTOPS
05/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A161.2	(1998) Decorative Laminate Countertops, Performance Standards for Fabricated High Pressure

ASME INTERNATIONAL (ASME)

ASME B18.6.1	(1981; R 2008) Wood Screws (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM D13	(2002) Standard Specification for Spirits of Turpentine
ASTM D2583	(2007) Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM D4689	(2012) Standard Specification for Adhesive, Casein-Type
ASTM D4690	(2012) Standard Specification for Urea Formaldehyde Resin Adhesives
ASTM D570	(1998; E 2010; R 2010) Standard Test Method for Water Absorption of Plastics

ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F594	(2009; E 2011) Standard Specification for Stainless Steel Nuts
ASTM F836M	(2002; R 2010) Standard Specification for Style 1 Stainless Steel Metric Nuts

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO Z124.3	(2005) Plastic Lavatories

INTERNATIONAL CODE COUNCIL (ICC)

ICC IPC	(2012) International Plumbing Code

KITCHEN CABINET MANUFACTURERS ASSOCIATION (KCMA)

KCMA A161.1	(2000) Performance & Construction Standards for Kitchen and Vanity Cabinets

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA LD 3	(2005) Standard for High-Pressure Decorative Laminates

SCIENTIFIC EQUIPMENT AND FURNITURE ASSOCIATION (SEFA)

SEFA 7	(1996) Recommended Practice for Laboratory and Hospital Service Fittings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS FF-B-588	(Rev E; Notice 1) Bolt, Toggle: and Expansion Sleeve, Screw
FS FF-S-325	(Basic; Int Amd 3; Notices 3, 4) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS MM-L-751	(Rev H) Lumber; Softwood
FS TT-C-490	(Rev E) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
FS TT-C-520	(Rev B; Notice 1) Coating Compound, Bituminous, Solvent Type, Underbody (for Motor Vehicles)
FS TT-E-491	(Rev C; Notice 1) Enamel; Gloss, Synthetic (for Metal and Wood Furniture)

FS TT-F-336	(Rev E; Notice 1) Filler, Wood, Paste
FS TT-V-121	(Rev H; Notice 1) Varnish, Spar, Water-Resisting
FS WW-P-541	(Rev E; Am 1; Notice 1) Plumbing Fixtures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Countertop; G
Joint Sealants; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions; G

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle countertops and backsplash in a manner that will prevent damage and disfigurement.

Provide temporary skids under units as indicated on contract drawings.

1.4 DESIGN

Provide factory fabricated, prefinished steel countertops in the manufacturer's standard sizes and finishes of the type, design, and configuration indicated. Construct countertops as specified and meet the requirements of KCMA A161.1. Accomplish fastenings to permit removal and replacement of individual units without affecting the remainder of the installation. Provide counters with watertight sink rim when indicated. Include removable drawers equipped with position stops to avoid accidental complete withdrawals.

PART 2 PRODUCTS

2.1 GENERAL

Submit manufacturer's standard color charts for countertops showing the manufacturer's recommended color and finish selections.

Submit manufacturer's instructions for countertops including special provisions required to install equipment components and system packages. Include all special notices detailing impedances, hazards and safety precautions.

Provide the manufacturer's standard type countertops or as indicated on the drawings. Accomplish fastenings to permit removal and replacement of individual countertops without affecting the remainder of the installation.

2.2 MATERIALS

Provide corrosion-resistant steel conforming to ASTM A1008/A1008M and ASTM A167, Type 304 Finish 4.

Provide Douglas-fir plywood conforming to ICC IPC, exterior type, fully waterproof bond.

Use thermosetting urea-resin Type II Adhesives for application of plastic laminate conforming to ASTM D4690 as recommended by the manufacturer of the laminate. Use adhesive for wood members conforming to ASTM D4689.

Use filler material conforming to FS TT-F-336.

Provide plastic laminate conforming to ANSI/NEMA LD 3, Style, Type, Grade, Class, and Finish as indicated on contract drawings.

Provide softwoods conforming to FS MM-L-751, factory and shop grade.

Provide turpentine conforming to ASTM D13.

Provide varnish conforming to FS TT-V-121.

Provide fasteners conforming to the following:

Screws: ASME B18.6.1, Group, Type and Class as applicable

Anchoring Devices: FS FF-S-325, Group, Type, and Class as applicable

Toggle Bolts: FS FF-B-588, Type I, Class A, Style 2

Nuts: ASTM F594, corrosion-resistant steel

Bolts: ASTM A325, heavy, hexagon head bolts corrosion-resistant steel

Nuts: ASTM F836M, corrosion-resistant steel

Bolts: ASTM A325M, heavy, hexagon head bolts corrosion-resistant steel

Corrosion-resistant Steel Sinks:

1.3 millimeter (18-gage) corrosion-resistant steel, integral with corrosion-resistant steel countertop, or

1.3 millimeter (18-gage) corrosion-resistant steel, nonintegral, self-rimming

Drain holes in center of bowl

Underside coated with 3 millimeter (1/8-inch) thick sound deadener

Die-form, seamless, raised edges at front and ends

Cove corners to 13 millimeter (1/2-inch) radius

Equip with strainers and tail pieces

Sound deadening: Conform to FS TT-C-520.

Provide service fixtures conforming to the following requirements:

Fixtures: In accordance with the water conservation policy as stated in the International Plumbing Code, ICC IPC, Appendix J.

Faucets: Splashback mounted, cast brass, chrome plated, FS WW-P-541

Faucets: Deck mounted, cast brass, chrome plated, FS WW-P-541

Gas, air, and vacuum, distilled water, steam, and de-ionized water cocks: Cast brass, chrome plated, ground key type

Drains, strainers, and taps: Brass, chrome plated, FS WW-P-541

Index buttons: Plastic, color codes in accordance with SEFA 7

Special items: Nipples and locknuts with each fixture will be as directed.

Metal pretreatment coatings: FS TT-C-490, Type I, II, or III, as indicated.

Enamel: FS TT-E-491, Class 2

2.3 COUNTERTOP AND BACKSPLASH FABRICATION

Construct countertops and backsplash of Granite, Marble, Synthetic resin, Stainless steel, Tile, or FRP covered with a shop-applied plastic laminate, corrosion-resistant steel, or an integral corrosion-resistant steel top without backing according to ANSI A161.2, as indicated on contract drawings.

Provide steel no lighter than 0.85 millimeter (22-gage) corrosion-resistant steel for backed construction and not lighter than 1.3 millimeter (18-gage) corrosion-resistant steel for integral construction. Reinforce steel tops on edges and around sink-rim opening. Provide counters of one-piece construction; where corrosion-resistant sink bowls are provided, weld and polish smooth all joints. Make joints between sink, countertop, and backsplash watertight. Provide backsplash of the same material as countertop and form with square edges, and height as indicated.

Provide continuous sheet laminate of the longest length practicable and of the design and color selected. Provide joints in the surface sheeting that are tight and flush, and held to a practical minimum number.

Edging and trim:

For plastic-laminate-covered countertops and backsplash, provide edging and trim consisting of:

Strips of laminate cut and fitted to exposed edges with contact adhesive

Corrosion-resistant steel molding applied to exposed edges and at the intersection of the top and backsplash with a concealed fastening system

For corrosion-resistant steel countertops and backsplash, form the edging and trim as an integral part of the top.

Provide sink rims which are the standard products of a manufacturer regularly producing this type of equipment, fabricated from corrosion-resistant steel of the size necessary to receive the sinks.

2.3.1 High-Pressure Laminated Plastic Clad Countertops

Construct clad countertop and backsplash of 20 mm (3/4 inch) thick plywood or 20 mm (3/4 inch) thick, 20 kg (44 pound) density particle board core, post formed cove type or fully formed type. Or provide single unit cove type unit with self-edging and plastic laminate coved at the juncture of the countertop and backsplash. Or provide fully formed type or square edge unit with shaped edges using wood nose molding at counter edge,including a separate backsplash not less than 90 mm (3-1/2 inch) high. Provide edging and trim that consists of plastic laminate cut and fitted to all exposed edges. Supply end splashes constructed of 20 mm (3/4 inch) plywood or 20 mm (3/4 inch) thick, 20 kg (44 pound) density particle board core. Provide continuous sheets of longest lengths practicable. Make all joints in surface sheeting tight and flush. When the countertop and backsplash are two separate units, use GP50 plastic laminate. When the countertop and backsplash are one unit, use PF42 plastic laminate. Provide plastic laminate conforming to the requirements of ANSI/NEMA LD 3, with contact type plastic laminate adhesive applied to both surfaces. For fully formed and cove type countertops, the post-forming plastic laminate can not be bent to a radius smaller than the limit recommended by the plastic manufacturer.

2.3.2 Solid Polymer Countertops

Construct countertop and backsplash with integral sink and lavatory; unless otherwise indicated on contract drawings, with 19 mm (3/4 inch) material thickness, cast, and filled nonporous solid surfacing composed of acrylic polymer, mineral fillers, and pigments. Repair superficial damage, a depth of no more than 0.25 mm (0.010 inch), by sanding or polishing. Use material conforming to the following performance requirements:

a. Tensile Strength; 18.3 N/mm^2 (4100 psi), when tested in accordance with ASTM D638.

b. Hardness; Barcol Impressor 50 when tested in accordance with ASTM D2583.

c. Flammability; rated Class I with a flame spread of 25 maximum and a smoke developed of 100 maximum when tested in accordance with ASTM E84.

d. Boiling water resistance; no effect when tested in accordance with ANSI/NEMA LD 3.

e. High temperature; no effect when tested in accordance with ANSI/NEMA LD 3.

f. Liquid absorption; 0.06 percent maximum (24 hours) when tested in accordance with ASTM D570.

g. Sanitation; National Sanitation Foundation approval for food contact in accordance with Standard 51 and approval for food area applications.

h. Impact resistance; no failure for ball drop when tested in accordance with ANSI/NEMA LD 3.

2.3.3 Solid Polyester Resin Cultured Marble Countertops

Construct countertop and backsplash with integral sink and lavatory; unless otherwise indicated on contract drawings. Use material of 19 mm (3/4 inch) thickness minimum, cast, and filled nonporous solid surfacing composed of polyester resin crushed marble, glass frit, mineral fillers and pigments. Material is to comply with IAPMO Z124.3 and the following performance requirement; Flammability: Class I, flame spread of 25 maximum, smoke developed of 100 maximum when tested in accordance with ASTM E84.

2.4 SURFACING

2.4.1 Laminated Plastic Surfacing

Laminate plastic sheeting to faces and exposed edges of particle board at 138 kilopascal and 85 degrees C (20 pounds per square inch and 185 degrees F).

Apply backing sheet to concealed faces.

2.4.2 Corrosion-Resistant Steel Surfacing

Form counters and work surfaces of 1.6 millimeter (16-gage) sheets with exposed edges returned.

Use hat-shaped channels, 1.6 millimeter (16-gage), for reinforcement, spaced 760 millimeter (30 inches) on center.

Equip surfaces with wood strips under edges for fastening to cabinets.

Cove internal corners to 15 millimeter (1/2-inch) radius.

Coat underside with 3 millimeter (1/8-inch) thick sound deadener.

Electrically weld all joints, grind smooth, and polish to match adjacent finish.

2.5 ACCESSORIES AND HARDWARE

2.5.1 Mounting Adhesives

Provide structural-grade silicone or epoxy adhesives of type recommended by manufacturer for application and conditions of use.

Provide spacers, if required, of type recommended by adhesive manufacturer.

2.5.2 Stone Adhesive

Provide epoxy or polyester adhesive of type recommend by manufacturer for application and conditions of use.

If adhesive will be visible in finished work, tint adhesive to match surfacing.

2.5.3 Joint Sealants

Use clear silicone sealant of type recommended by manufacturer for application and conditions of use.

Provide anti-bacterial type in toilet, bathrooms,and food preparation areas.

2.5.4 Solvent

Use a product recommended by adhesive manufacturer to clean surface of quartz surfacing to assure adhesion of adhesives and sealants.

2.5.5 Cleaning Agents

Use non-abrasive, soft-scrub type kitchen cleaners.

2.6 COLOR, TEXTURE, AND PATTERN

Select color as indicated on the drawings. Color listed is not intended to limit the selection of equal colors from other manufacturers.

2.7 LOCAL PRODUCTS

Local materials manufactured in the Republic of Korea authorized by USA EDFE Local Material Committee may be used in lieu of standard products as required under the contractor's quality control approval. These materials should be certified and listed in the Korean Industrial Standards (KS) at a minimum and may be subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 INSTALLATION

Inspect material for defects prior to installation. Ensure materials throughout bear labels with the same batch number. Visually inspect materials used for adjacent pieces to assure acceptable color match. Inspect in lighting conditions similar to those on the project. Repair or replace damaged materials in a satisfactory manner.

Install countertops plumb with cabinetry level to within 1 millimeter in 3000 millimeter (1/16 inch in 10 feet). Level base cabinets by adjusting leveling screws. Scribe and fit scribe strips to irregularities of adjacent surfaces. Gap openings exceeding 0.63 millimeter (0.025 inch) are not acceptable.

Secure countertops to cabinetry and wall construction using 6 millimeter (1/4-inch) diameter masonry anchors, spaced 760 millimeter (30 inches) maximum on center.

Submit installation drawings for countertops. Ensure drawings include location of cabinets, details of cabinets related and dimensional positions, and locations for roughing in plumbing, including sinks, faucets, strainers and cocks.

3.1.1 Preliminary Installation and Adjustment

Install materials in accordance to manufacturer's recommendations. Lift and place to avoid breakage.

Position materials to verify that materials are correctly sized and prepared. Make necessary adjustments.

If jobsite cutting, grinding, or polishing is required, use water-cooled tools. Protect jobsite and surfaces against dust and water. Perform work away from installation site if possible.

Gypsum drywall back walls which are not fire or acoustically rated may be routed up to half the thickness of the drywall to allow countertop to fit.

Shim countertop drainage adjacent to sinks and where drainage is required, slightly to insure positive drainage.

3.1.2 Permanent Installation

After verifying fit, remove quartz surfacing from position, clean substrates of dust and contamination, and clean quartz surfacing back side and joints with solvent.

Apply sufficient quantity of mounting adhesive in accordance with adhesive manufacturer's recommendations to provide permanent, secure installation.

Install surfacing plumb, level, and square and flat to within 1.6 mm in 3 meters (1/6 inch in 10 feet).

3.1.3 Joints

Ensure joints between adjacent pieces of quartz surfacing are:

Flush, tight fitting, level, and neat.

Securely joined with stone adhesive. Fill joints level with quartz surfacing.

Clamp or brace quartz surfacing in position until adhesive sets.

Joints between backsplashes and countertops and around tub and shower enclosures: Seal joints with silicone sealer.

3.2 CLEANING

On completion of cabinet installation, touch up marred or abraded finished surfaces. Remove crating and packing materials from premises. Wipe down surfaces to remove fingerprints and markings and leave in clean condition.

3.3 INSPECTION

Examine casework grounds and supports for adequate anchorage, foreign material, moisture, and unevenness that could prevent quality casework installation.

Ensure that electrical and plumbing rough-ins for casework are complete. Do not proceed with installation until defects are corrected.

-- End of Section --

SECTION 13 48 00.00 10

SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2011) Steel Construction Manual

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for seismic protection measures described in this section to the mechanical equipment and systems listed below. Structural requirements shall be in accordance with Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.2.2 Mechanical Equipment

Mechanical equipment to be seismically protected shall include the following items to the extent required on the drawings or in other sections of these specifications:

Boilers and furnaces	Storage Tanks for Oil and Water
Water Heaters	Steam, Water, Oil and Gas Piping
Expansion Air Separator Tanks	Valves and Fittings for Piping
Heat Exchangers	Steam-fed Kitchen Appliances
Water Chiller Units	Thermal Storage Units
Cooling Towers	Air and Refrigerant Compressors
Refrigerant Piping	Air Handling Units
Pumps with Motors	Lab Scrubbers
Large Commercial Dryers	Pollution Control Equipment
Gas Dryers	Ducts
Flash Tanks	Unit Heaters
Accumulator Tank	Exhaust and Return Fans
Solar Heating Units	

1.2.3 Mechanical Systems

Install the following mechanical systems as required on the drawings and other sections of these specifications and seismically protect them in accordance with this specification:

a. All Piping Inside the Building Except as Specifically Stated Below Under "Items Not Covered By This Section".

b. Chilled Water Distribution Systems Outside of Buildings.

c. Fuel Piping Outside of Buildings.

d. All Water Supply Systems.

e. Storm and Sanitary Sewer Systems.

f. All Process Piping.

g. Heat Distribution Systems (Supply, Return, and Condensate Return) Outside of Buildings.

h. Condenser Water Piping Outside the Building.

i. Pneumatic Tube Distribution System.

j. Cold Storage Refrigeration Systems

k. Fuel Storage Tanks.

l. Water Storage Tanks.

1.2.4 Contractor Designed Bracing

Submit copies of the design calculations with the drawings. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-310-04 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-310-04 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-310-04 are based on strength design; therefore, AISC 325 Specifications shall be used for the design. The bracing for the mechanical equipment and systems to be provided under this contract shall be developed by the Contractor.

1.2.5 Items Not Covered By This Section

1.2.5.1 Fire Protection Systems

Seismic protection of piping for fire protection systems shall be installed as specified in Sections 21 30 00 FIRE PUMPS, 21 13 13.00 10 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION, 21 13 17.00 10 DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION, 21 13 18.00 10 PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION, and 21 13 24.00 10 AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM.

1.2.5.2 Items Requiring No Seismic Restraints

Seismic restraints are not required for the following items:

a. Gas piping less than 25 mm (1 inch) inside diameter.

b. Piping in boiler and mechanical equipment rooms less than 32 mm (1-1/4 inches) inside diameter.

c. All other piping less than 64 mm (2-1/2inches) inside diameter.

d. Rectangular air handling ducts less than 0.56 square meters (6 square feet) in cross sectional area.

e. Round air handling ducts less than 711 mm (28 inches) in diameter.

f. Piping suspended by individual hangers 300 mm (12 inches) or less in length from the top of pipe to the bottom of the supporting structural member where the hanger is attached, except as noted below.

g. Ducts suspended by hangers 300 mm (12 inches) or less in length from the top of the duct to the bottom of the supporting structural member, except as noted below.

In exemptions f. and g. all hangers shall meet the length requirements. If the length requirement is exceeded by one hanger in the run, the entire run shall be braced. Interior piping and ducts not listed above shall be seismically protected in accordance with the provisions of this specification.

1.3 EQUIPMENT REQUIREMENTS

Submit copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.1.3.1 Rigidly Mounted Equipment

The following specific items of equipment to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04. Each item of rigid equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, duct, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Boilers
Chillers
Air-Handling Units
Cooling Towers
Surge Tanks

1.3.2 Nonrigid or Flexibly-Mounted Equipment

The following specific items of equipment to be furnished shall be constructed and assembled to resist a horizontal lateral force of 0.10 times the operating weight of the equipment at the vertical center of gravity of the equipment, unless otherwise indicated on contract drawings/documents.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Coupling and Bracing
Flexible Couplings or Joints
Equipment Requirements
Contractor Designed Bracing; G.

SD-03 Product Data

Coupling and Bracing; G.
Equipment Requirements; G.
Contractor Designed Bracing; G.

SD-07 Certificates

Flexible Ball Joints.

PART 2 PRODUCTS

2.1 FLEXIBLE COUPLINGS

Flexible couplings shall have same pressure and temperature ratings as adjoining pipe.

2.2 FLEXIBLE BALL JOINTS

Flexible ball joints shall have cast or wrought steel casing and ball parts capable of 360-degree rotation with not less than 15-degree angular movement. Flexible ball joints shall be certified to be suitable for the service intended by the manufacturer. Information verifying experience at not less than 3 locations of 2 years' satisfactory operation in a similar application shall be submitted.

2.3 FLEXIBLE MECHANICAL JOINTS

a. Mechanical couplings for steel or cast iron pipe shall be of the sleeve type and shall provide a tight flexible joint under all reasonable conditions, such as pipe movement caused by expansion, contraction, slight settling or shifting of the ground, minor variations in trench gradients, and traffic vibrations. Where permitted in other sections of these specifications, joints utilizing split-half couplings with grooved or shouldered pipe ends may be used.

b. Sleeve-type couplings shall be used for joining plain-end pipe sections. The coupling shall consist of one steel middle ring, two steel followers, two gaskets, and necessary steel bolts and nuts to compress the gaskets.

2.4 MANUFACTURED BALL JOINTS

Manufactured ball joints shall be as recommended by the manufacturer for the intended use, and shall be approved by the Contracting Officer before installation.

2.5 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 COUPLING AND BRACING

a. Submit detail drawings, as specified here and throughout this specification, along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction.

b. Coupling installation shall conform to the details shown on the drawings. Provisions of this paragraph apply to all piping within a 1.5 m (5 foot) line around outside of building unless buried in the ground. Piping grouped for support on trapeze-type hangers shall be braced at the most frequent interval as determined by applying the requirements of this specification to each piping run on the common support.

c. Bracing components shall be sized as required for the total load carried by the common supports. Bracing rigidly attached to pipe flanges, or similar, shall not be used where it would interfere with thermal expansion of piping.

3.2 BUILDING DRIFT

Joints capable of accommodating seismic displacements shall be provided for vertical piping between floors of the building, where pipes pass through a building seismic or expansion joint, or where rigidly supported pipes connect to equipment with vibration isolators. Horizontal piping across expansion joints shall accommodate the resultant of the drifts of each building unit in each orthogonal direction. For threaded piping, swing joints made of the same piping material shall be provided. For piping with manufactured ball joints the seismic drift shall be 0.015 meters per meter (0.049 feet per foot) of height above the base where the seismic separation occurs; this drift value shall be used in place of the expansion given in the manufacturer's selection table.

3.3 FLEXIBLE COUPLINGS OR JOINTS

3.3.1 Building Piping

Flexible couplings or joints in building piping shall be provided at bottom of all pipe risers for pipe larger than 90 mm (3-1/2 inches) in diameter. Flexible couplings or joints shall be braced laterally without interfering with the action of the flexible coupling or joint. Cast iron waste and vent piping need only comply with these provisions when caulked joints are used. Flexible bell and spigot pipe joints using rubber gaskets may be used at each branch adjacent to tees and elbows for underground waste piping inside of building to satisfy these requirements.

3.3.2 Underground Piping

Underground piping and 100 mm (4 inch) or larger conduit, except heat distribution system, shall have flexible couplings installed where the piping enters the building. The couplings shall accommodate 1900 mm (76 inches) of relative movement between the pipe and the building in any direction. Additional flexible couplings shall be provided where shown on the drawings.

3.4 PIPE SLEEVES

Pipe sleeves in interior non-fire rated walls shall be sized as indicated on the drawings to provide clearances that will permit differential movement of piping without the piping striking the pipe sleeve. Pipe sleeves in fire rated walls shall conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.5 SPREADERS

Spreaders shall be provided between adjacent piping runs to prevent contact during seismic activity whenever pipe or insulated pipe surfaces are less than 100 mm (4 inches) apart. Spreaders shall be applied at same interval as sway braces at an equal distance between the sway braces. If rack type hangers are used where the pipes are restrained from contact by mounting to the rack, spreaders are not required for pipes mounted in the rack. Spreaders shall be applied to surface of bare pipe and over insulation on insulated pipes utilizing high-density inserts and pipe protection shields in accordance with the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.6 SWAY BRACES FOR PIPING

Sway braces shall be provided to prevent movement of the pipes under seismic loading. Braces shall be provided in both the longitudinal and transverse directions, relative to the axis of the pipe. The bracing shall not interfere with thermal expansion requirements for the pipes as described in other sections of these specifications.

3.6.1 Transverse Sway Bracing

Transverse sway bracing for steel and copper pipe shall be provided as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT. All runs (length of pipe between end joints) shall have a minimum of two transverse braces. Transverse sway bracing for pipes of materials other than steel and copper shall be provided at intervals not to exceed the hanger spacing as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.6.2 Longitudinal Sway Bracing

Longitudinal sway bracing shall be provided at 12 m (40 foot) intervals unless otherwise indicated. All runs (length of pipe between end joints) shall have one longitudinal brace minimum. Sway braces shall be constructed in accordance with the drawings. Branch lines, walls, or floors shall not be used as sway braces.

3.6.3 Vertical Runs

Run is defined as length of pipe between end joints. Vertical runs of piping shall be braced at not more than 3 m (10 foot) vertical intervals. Braces for vertical runs shall be above the center of gravity of the segment being braced. All sway braces shall be constructed in accordance with the drawings. Sway braces shall attach to the structural system and shall not be connected to branch lines, walls, or floors.

3.6.4 Clamps and Hangers

Clamps or hangers on uninsulated pipes shall be applied directly to pipe. Insulated piping shall have clamps or hangers applied over insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.7 SWAY BRACES FOR DUCTS

3.7.1 Braced Ducts

Bracing details and spacing for rectangular and round ducts shall be in accordance with SMACNA 1981, including Appendix E and UFC 3-310-04. However, the design seismic loadings for these items shall not be less than loadings obtained using the procedures in UFC 3-310-04.

3.7.2 Unbraced Ducts

Hangers for unbraced ducts shall be attached to the duct within 50 mm (2 inches) of the top of the duct in accordance with SMACNA 1981. Unbraced ducts shall be installed with a 150 mm (6 inch) minimum clearance to vertical ceiling hanger wires.

-- End of Section --

SECTION 13 48 00

SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT
08/08

PART 1   GENERAL

1.1   REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)

ASTM A572/A572M	(2012) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A603	(1998; R 2009e1) Standard Specification for Zinc-Coated Steel Structural Wire Rope
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM E488/E488M	(2010) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for seismic protection measures, described in this section, to the mechanical equipment and systems outlined in Section 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, the electrical equipment and systems outlined in Section 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT, and the miscellaneous equipment and systems listed below, in accordance with UFC 3-310-04 and additional data furnished by the Contracting Officer. Provide seismic protection measures in addition to any other requirements called for in other sections of these specifications. The design for seismic protection shall be based on a Seismic Use Group I building occupancy and on site response coefficients for S_{MS} = .11 and S_{M1} = 1.4, unless otherwise indicated in contract drawings or specifications. Accomplish resistance to lateral forces induced by earthquakes without consideration of friction resulting from gravity loads. The basic force formulas, for Ground Motions A and B in UFC 3-310-04, use the design spectral response acceleration parameters for the performance objective of the building, not for equipment in the building; therefore, corresponding adjustments to the formulas are required.

1.2.2 Miscellaneous Equipment and Systems

The bracing for the following miscellaneous equipment and systems shall be developed by the Contractor in accordance with the requirements of this specification:

- Storage cabinets
- Storage Racks
- Shelving
- Partitions
- Ornamentations
- Signs and Billboards
- Furnishings

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings, as specified here and throughout this specification, along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall: be complete in detail; indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction. For equipment and systems in buildings that have a performance objective higher than life-safety, the drawings shall be stamped by the registered engineer who stamps the calculations required above. Submit copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer, and verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

Equipment to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04. For any rigid equipment which is rigidly attached on both sides of a building expansion joint, provide flexible joints for piping, electrical conduit, etc., that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

1.3.2 Nonrigid or Flexibly-Mounted Equipment

Equipment to be furnished shall be constructed and assembled to resist a horizontal lateral force of 0.10 times the operating weight of the equipment at the vertical center of gravity of the equipment, unless otherwise indicated on contract drawings/documents.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Bracing; G
Resilient Vibration Isolation Devices; G
Equipment Requirements; G

SD-03 Product Data

Bracing; G
Equipment Requirements; G

SD-06 Test Reports

Anchor Bolts

PART 2 PRODUCTS

2.1 BOLTS AND NUTS

Squarehead and hexhead bolts, and heavy hexagon nuts, ASME B18.2.1, ASME B18.2.2, or ASTM A307 for bolts and ASTM A563M (ASTM A563) for nuts ASTM A325M (ASTM A325) for bolts and nuts. Provide bolts and nuts galvanized in accordance with ASTM A153/A153M when used underground and/or exposed to weather.

2.2 SWAY BRACING

Material used for members listed in this section and on the drawings, shall be structural steel conforming with the following:

a. Plates, rods, and rolled shapes, ASTM A36/A36M or ASTM A572/A572M, Grade 503. If the Contractor does the design, both ASTM A36/A36M and ASTM A572/A572M, grade 503 will be allowed.

b. Wire rope, ASTM A603.

c. Tubes, ASTM A500/A500M, Grade B.

d. Pipes, ASTM A53/A53M, Type E or S, Grade B.

e. Light gauge angles, less than 6 mm (1/4 inch) thickness, ASTM A653/A653M.

PART 3 EXECUTION

3.1 BRACING

Provide bracing conforming to the arrangements shown. Secure trapeze-type hanger with not less than two 13 mm (1/2 inch) bolts.

3.2 BUILDING DRIFT

Sway braces for a piping run shall not be attached to two dissimilar structural elements of a building that may respond differentially during an earthquake unless a flexible joint is provided.

3.3 ANCHOR BOLTS

Submit copies of test results to verify the adequacy of the specific anchor and application, as specified.

3.3.1 Cast-In-Place

Use cast-in-place anchor bolts, conforming to ASTM A307, for floor or pad mounted equipment, except as specified below. Provide one nut on each bolt. Anchor bolts shall have an embedded straight length equal to at least 12 times nominal diameter of the bolt. Anchor bolts that exceed the normal depth of equipment foundation piers or pads shall either extend into concrete floor or the foundation or be increased in depth to accommodate bolt lengths.

3.3.2 Expansion or Chemically Bonded Anchors

Do not use expansion or chemically bonded anchors: 1) Unless test data in accordance with ASTM E488/E488M has been provided to verify the adequacy of the specific anchor and application. 2) To resist pull-out in overhead and wall installations if the adhesive is manufactured with temperature sensitive epoxies and the location is accessible to a building fire. Install expansion and chemically bonded anchors in accordance with the manufacturer's recommendations. Adjust the allowable forces for the spacing between anchor bolts and the distance between the anchor bolt and the nearest edge, as specified by the manufacturer.

3.3.2.1 General Testing

Test in place expansion and chemically bonded anchors not more than 24 hours after installation of the anchor, conducted by an independent testing agency; testing shall be performed on random anchor bolts as described below.

3.3.2.2 Torque Wrench Testing

Perform torque wrench testing on not less than 50 percent of the total installed expansion anchors and at least one anchor for every piece of equipment containing more than two anchors. The test torque shall equal the minimum required installation torque as required by the bolt manufacturer. Calibrate torque wrenches at the beginning of each day the torque tests are performed. Recalibrate torque wrenches for each bolt diameter whenever tests are run on bolts of various diameters. Apply torque between 20 and 100 percent of wrench capacity. Reach the test torque within one half turn of the nut, except for 9 mm (3/8 inch) sleeve anchors which shall reach their torque by one quarter turn of the nut. If any anchor fails the test, test similar anchors not previously tested until 20 consecutive anchors pass. Failed anchors shall be retightened and retested to the specified torque; if the anchor still fails the test it shall be replaced.

3.3.2.3 Pullout Testing

Test expansion and chemically bonded anchors by applying a pullout load using a hydraulic ram attached to the anchor bolt. At least 5 percent of the anchors, but not less than 3 per day shall be tested. Apply the load to the anchor without removing the nut; when that is not possible, the nut shall be removed and a threaded coupler shall be installed of the same tightness as the original nut. Check the test setup to verify that the anchor is not restrained from withdrawing by the base plate, the test fixture, or any other fixtures. The support for the testing apparatus shall be at least 1.5 times the embedment length away from the bolt being tested. Load each tested anchor to 1 times the design tension value for the anchor. The anchor shall have no observable movement at the test load. If any anchor fails the test, similar anchors not previously tested shall be tested until 20 consecutive anchors pass. Failed anchors shall be retightened and retested to the specified load; if the anchor still fails the test it shall be replaced.

3.4 RESILIENT VIBRATION ISOLATION DEVICES

Where the need for these devices is determined, based on the magnitude of the design seismic forces, selection of anchor bolts for vibration isolation devices and/or snubbers for equipment base and foundations shall follow the same procedure as in paragraph ANCHOR BOLTS, except that an equipment weight equal to five times the actual equipment weight shall be used.

3.4.1 Resilient and Spring-Type Vibration Devices

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 13 mm (1/2 inch).

3.4.2 Multidirectional Seismic Snubbers

Install multidirectional seismic snubbers employing elastomeric pads on floor- or slab-mounted equipment. These snubbers shall provide 6 mm (1/4 inch) free vertical and horizontal movement from the static deflection point. Snubber medium shall consist of multiple pads of cotton duct and neoprene or other suitable materials arranged around a flanged steel trunnion so both horizontal and vertical forces are resisted by the snubber medium.

3.5 SWAY BRACES FOR PIPING

Provide transverse sway bracing for steel and copper pipe at intervals not to exceed those shown on the drawings. Transverse sway bracing for pipes of materials other than steel and copper shall be provided at intervals not to exceed the hanger spacing as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Provide bracing consisting of at least one vertical angle 50 by 50 mm by 16 gauge (2 by 2 inch by 16 gauge) and one diagonal angle of the same size.

3.5.1 Longitudinal Sway Bracing

Provide longitudinal sway bracing in accordance with Section 13 48 00.00 10 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

3.5.2 Anchor Rods, Angles, and Bars

Anchor rods, angles, and bars shall be bolted to either pipe clamps or pipe flanges at one end and cast-in-place concrete or masonry insert or clip angles bolted to the steel structure on the other end. Rods shall be solid metal or pipe as specified below. Anchor rods, angles, and bars shall not exceed lengths given in the tabulation below.

3.5.3 Maximum Length for Anchor Braces

Type	Size (millimeters)	Maximum Length* (meters)
Angles	38 x 38 x 6	1.5
	50 x 50 x 6	2.0
	64 x 38 x 6	2.5
	75 x 64 x 6	2.5
	75 x 75 x 6	3.0
Rods	91	1.0
	22	1.0
Flat Bars	38 x 6	0.4
	50 x 6	0.4
	50 x 10	0.5
Pipes (40s)	25	2.0
	32	2.8
	40	3.2
	50	4.0

Type	Size (Inches)	Maximum Length* (Feet/Inches)
Angles	1-1/2 x 1-1/2 x 1/4	4-10

Type	Size (Inches)	Maximum Length* (Feet/Inches)
	2 x 2 x 1/4	6-6
	2-1/2 x 1-1/2 x 1/4	8-0
	3 x 2-1/2 x 1/4	8-10
	3 x 3 x 1/4	9-10
Rods	3/4	3-1
	7/8	3-8
Flat Bars	1-1/2 x 1/4	1-2
	2 x 1/4	1-2
	2 x 3/8	1-9
Pipes (40S)	1	7-0
	1-1/4	9-0
	1-1/2	10-4
	2	13-1

3.5.4 Bolts

Bolts used for attachment of anchors to pipe and structure shall be not less than 13 mm (1/2 inch) diameter.

3.6 EQUIPMENT SWAY BRACING

3.6.1 Suspended Equipment and Light Fixtures

Provide equipment sway bracing for items supported from overhead floor or roof structural systems, including light fixtures. Braces shall consist of angles, rods, wire rope, bars, or pipes arranged as shown and secured at both ends with not less than 13 mm (1/2 inch) bolts. Provide sufficient braces for equipment to resist a horizontal force as specified in UFC 3-310-04 without exceeding safe working stress of bracing components. Provide, for approval, specific force calculations in accordance with UFC 3-310-04 for the equipment in the project. Submit details of equipment bracing for acceptance. In lieu of bracing with vertical supports, these items may be supported with hangers inclined at 45 degrees directed up and radially away from equipment and oriented symmetrically in 90-degree intervals on the horizontal plane, bisecting the angles of each corner of the equipment, provided that supporting members are properly sized to support operating weight of equipment when hangers are inclined at a 45-degree angle.

3.6.2 Floor or Pad Mounted Equipment

3.6.2.1 Shear Resistance

Bolt to the floor, floor mounted equipment. Requirements for the number and installation of bolts to resist shear forces shall be in accordance with paragraph ANCHOR BOLTS.

3.6.2.2 Overturning Resistance

Use the ratio of the overturning moment from seismic forces to the resisting moment due to gravity loads to determine if overturning forces need to be considered in the sizing of anchor bolts. Provide calculations to verify the adequacy of the anchor bolts for combined shear and overturning.

-- End of Section --

SECTION 21 13 13.00 10

WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
05/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1015	(2009) Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.9	(2012) Standard for Factory-Made Wrought

	Steel Buttwelding Fittings
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A795/A795M	(2013) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM F436	(2011) Hardened Steel Washers
ASTM F436M	(2011) Hardened Steel Washers (Metric)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code
NFPA 13	(2013; TIA 10-1; TIA 11-2; ERTA 2014; TIA 14-3) Standard for the Installation of Sprinkler Systems
NFPA 13D	(2013) Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
NFPA 13R	(2013) Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height
NFPA 1963	(2014) Standard for Fire Hose Connections
NFPA 24	(2013) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2010) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Water Based Systems Layout

UNDERWRITERS LABORATORIES (UL)

UL 668	(2004; Reprint Dec 2012) Hose Valves for Fire-Protection Service
UL Bld Mat Dir	(2012) Building Materials Directory
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1004	(2012) Square Head Bolts
KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1533	(2009) Screwed Type Steel Pipe Fittings
KS B 1541	(2009) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel socket-welding pipe Fittings
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service

KS D 4308	(2012) Ductile Iron Fittings
KS D 4311	(2010) Ductile Iron Pipes
KS D 4316	(2012) Mortar Lining of Ductile Iron Pipes & Fittings
KS M 1103	(2008) Liquid Chlorine

1.2 SYSTEM DESCRIPTION

Furnish piping offsets, fittings, and any other accessories as required to provide a complete installation and to eliminate interference with other construction. Install sprinkler system over and under ducts, piping and platforms when such equipment can negatively effect or disrupt the sprinkler discharge pattern and coverage. Provide wet pipe sprinkler system in areas indicated on the drawings. The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, the system shall be designed and installed in accordance with NFPA 13 or NFPA 13R, as applicable. Rack sprinklers shall be in accordance with NFPA 13. Pipe sizes which are not indicated on drawings shall be determined by hydraulic calculation. Design any portions of the sprinkler system that are not indicated on the drawings including locating sprinklers, piping and equipment, and size piping and equipment when this information is not indicated on the drawings or is not specified herein. The Contractor shall design the sprinkler system based on hydraulic calculations, and the other provisions specified herein.

1.2.1 Hydraulic Design

Hydraulically design the system to discharge a minimum density over the hydraulically most demanding 280 square m area in compliance with NFPA 13. The minimum pipe size for branch lines in gridded systems shall be 32 mm (1-1/4 inch). Hydraulic calculations shall be in accordance with the Area/Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s (20 ft/s).

1.2.1.1 Hose Demand

Add an allowance for exterior hose streams to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building or at the point of connection to the existing system. An allowance for interior hose stations shall also be added to the sprinkler system demand.

1.2.1.2 Basis for Calculations

The design of the system shall be based upon water supply data indicated on drawings. Hydraulic calculations shall be based upon the Hazen-Williams formula with a "C" value of 120 for steel piping, 150 for copper tubing, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping. If a fire pump is required, hydraulic calculations shall be based on operation of the fire pump(s) provided in Section 21 30 00 FIRE PUMPS

1.2.1.3 Hydraulic Calculations

Submit hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments and as outlined in NFPA 13, except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall be based on the water supply data shown on the drawings to substantiate that the design area used in the calculations is the most demanding hydraulically. Water supply curves and system requirements shall be plotted on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. Provide a summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows. Elevations of hydraulic reference points (nodes) shall be indicated. Documentation shall identify each pipe individually and the nodes connected thereto. Indicate the diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient for each pipe. For gridded systems, calculations shall show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. Also for gridded systems, a flow diagram indicating the quantity and direction of flows shall be included. A drawing showing hydraulic reference points (nodes) and pipe designations used in the calculations shall be included and shall be independent of shop drawings.

1.2.2 Sprinkler Coverage

Sprinklers shall be uniformly spaced on branch lines. In buildings protected by automatic sprinklers, sprinklers shall provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms, boiler rooms, switchgear rooms, transformer rooms, and other electrical and mechanical spaces. Coverage per sprinkler shall be in accordance with NFPA 13, but shall not exceed 9 square m (100 square feet) for extra hazard occupancies, 12 square m (130 square feet) for ordinary hazard occupancies, and 21 square m (225 square feet) for light hazard occupancies. Exceptions are as follows:

a. Facilities that are designed in accordance with NFPA 13R and NFPA 13D.

b. Sprinklers may be omitted from small rooms which are exempted for specific occupancies in accordance with NFPA 101.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

One hard copy & one digital copy (.pdf - text searchable) of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

As-Built Drawings

As-built drawings, no later than 14 days after completion of Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-03 Product Data

Fire Protection Related Submittals; G

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Materials and Equipment; G

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Spare Parts

Spare parts data shall be included for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Onsite Training; G

Proposed Onsite Training schedule, at least 14 days prior to the start of related training.

SD-05 Design Data

Sway Bracing; G

For systems that are required to be protected against damage from earthquakes, load calculations shall be provided for sizing of sway bracing.

Hydraulic Calculations; G

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

SD-06 Test Reports

Preliminary Tests; G

Proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests and proposed date and time to begin the preliminary tests.

Preliminary Test Report; G

One hard copy & one digital copy (.pdf - text searchable) of the Test Report, no later that 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Test Report shall be signed by the Fire Protection Specialist.

Final Acceptance Test; G

Proposed procedures and notification for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests, and proposed date and time to begin the Test, submitted with the procedures. Notification shall include a copy of the Contractor's Material & Test Certificates.

Final Acceptance Test Report; G

One hard copy & one digital copy (.pdf - text searchable) of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Fire Protection Specialist; G

The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations.

Sprinkler System Installer; G

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

Inspection by Fire Protection Specialist; G

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals

One hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour on-site response to a service call on an emergency basis.

1.4 QUALITY ASSURANCE

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

1.4.1 Fire Protection Specialist

Perform work specified in this section under the supervision of and certified by the Fire Protection Specialist who is a registered professional engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES), is in a related engineering discipline with a minimum of 5 years experience dedicated to fire protection engineering that can be verified with documentation, or who is certified as a Level III or IV Technician by the National Institute for Certification in Engineering Technologies (NICET) in the Water Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. Submit the name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations. The Fire Protection Specialist shall prepare and submit a list of the fire protection related submittals, no later than 7 days after the approval of the Fire Protection Specialist, from the Contract Submittal Register that relate to the successful installation of the sprinkler systems(s). The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.2 Sprinkler System Installer

Work specified in this section shall be performed by the Sprinkler System Installer who is regularly engaged in the installation of the type and complexity of system specified in the contract documents, and who has served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months. Submit the name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

1.4.3 Shop Drawings

Shop Drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Submit one hard copy & one digital copy of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 (1/8" = 1'-0")which clearly show locations of sprinklers, risers, pipe hangers, seismic separation assemblies, sway bracing, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be indicated.

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; pipe hanger; sway bracing for earthquake protection, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring. Submit load calculations for sizing of sway bracing for systems that are required to be protected against damage from earthquakes.

1.5 DELIVERY, STORAGE, AND HANDLING

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.6 EXTRA MATERIALS

The Contractor shall submit spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Provide Materials and Equipment that have been tested by Underwriters Laboratories, Inc. and are listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE. Submit manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, provide a complete equipment list that includes equipment description, model number and quantity.

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe

Piping from a point 150 mm (6 inches) above the floor to a point 1500 mm (5 feet) outside the building wall or the point of connection to the existing water mains shall be ductile iron with a rated working pressure of 1034 or 1207 kPa150 or (175 psi) conforming to AWWA C151/A21.51 or KS D 4311, with cement mortar lining conforming to AWWA C104/A21.4 or KS D 4316. Piping more than 1500 mm (5 feet) outside the building walls shall comply with Section 33 11 00 WATER DISTRIBUTION.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to AWWA C110/A21.10 or KS D 4308. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to AWWA C111/A21.11 or KS D 4308.

2.4.3 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM APP GUIDE.

2.5 ABOVEGROUND PIPING COMPONENTS

Aboveground piping shall be steel.

2.5.1 Steel Piping Components

2.5.1.1 Steel Pipe

Except as modified herein, steel pipe shall be black as permitted by NFPA 13 and shall conform to applicable provisions of ASTM A795/A795M, ASTM A53/A53M, ASTM A135/A135M, or KS D 3562. Pipe in which threads or grooves are cut or rolled formed shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and ASTM designation.

2.5.1.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be cast iron conforming to ASME B16.4, steel conforming to ASME B16.9, ASME B16.11, KS B 1533, KS B 1541, or KS B 1542, or malleable iron conforming to ASME B16.3 or KS B 1531. Steel press fittings shall be approved for fire protection systems. Galvanized fittings shall be used for piping systems. Fittings into which sprinklers, drop nipples or riser nipples (sprigs) are screwed shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.1.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer;segmented welded fittings shall not be used. Fitting and coupling houses shall be malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.5.1.4 Flanges

Flanges shall conform to NFPA 13 and ASME B16.1. Gaskets shall be non-asbestos compressed material in accordance with ASME B16.21, 1.6 mm (1/16 inch) thick, and full face or self-centering flat ring type.

2.5.1.5 Bolts, Nut, and Washers

Bolts shall conform to ASTM A449, Type 1 and shall extend no less than three full threads beyond the nut with bolts tightened to the required torque. Bolts shall be squarehead conforming to ASME B18.2.1 or KS B 1004 Nuts shall be hexagon type conforming to ASME B18.2.2 or ASTM A193/A193M, Grade 5, Grade C3/DH3 or KS B 1012. Washers shall meet the requirements of ASTM F436M (ASTM F436). Flat circular washers shall be provided under all bolt heads and nuts.

2.5.2 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM APP GUIDE and of the type suitable for the application, construction, and pipe type and sized to be supported.

2.5.3 Valves

2.5.3.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM APP GUIDE.

2.5.3.2 Check Valve

Check valve 50 mm (2 inches) and larger shall be listed in UL Bld Mat Dir or FM APP GUIDE. Check valves 100 mm 4 inches) and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.5.3.3 Hose Valve

Valve shall comply with UL 668 and shall have a minimum rating of 2070 kPa (300 psi). Valve shall be non-rising stem, all bronze, 90 degree angle type, with 65 mm (2-1/2 inch) American National Standard Fire Hose Screw Thread (NH) male outlet in accordance with NFPA 1963. Hose valve shall be provided with 65 to 40 mm (2-1/2 to 1-1/2 inch) reducer. Hose valves shall be equipped with lugged cap with drip drain, cap gasket and chain. Valve finish shall be polished brass, rough chrome plated, or polished chrome plated.

2.6 ALARM CHECK VALVE ASSEMBLY

Assembly shall include an alarm check valve, standard trim piping, pressure gauges, bypass, retarding chamber, testing valves, main drain, and other components as required for a fully operational system.

2.7 WATERFLOW ALARM

Electrically operated, exterior-mounted, waterflow alarm bell shall be provided and installed in accordance with NFPA 13. Waterflow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel(FACP) in accordance with Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. Or, if indicated on contract drawings or specifications, mechanically operated, exterior-mounted, water motor alarm assembly shall be provided and installed in accordance with NFPA 13. Water motor alarm assembly shall include a body housing, impeller or pelton wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 19 mm (3/4 inc)h galvanized piping shall be provided between the housing and the alarm check valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and outside surfaces.

2.8 ALARM INITIATING AND SUPERVISORY DEVICES

2.8.1 Sprinkler Waterflow Indicator Switch, Vane Type

Switch shall be vane type with a pipe saddle and cast aluminum housing. The electro-mechanical device shall include a flexible, low-density polyethylene paddle conforming to the inside diameter of the fire protection pipe. The device shall sense water movements and be capable of detecting a sustained flow of 38 L/min (10 gpm) or greater. The device shall contain a retard device adjustable from 0 to 90 seconds to reduce the possibility of false alarms caused by transient flow surges. The switch shall be tamper resistant and contain two SPDT (Form C) contacts arranged to transfer upon removal of the housing cover, and shall be equipped with a silicone rubber gasket to assure positive water seal and a dust-proof cover and gasket to seal the mechanism from dirt and moisture.

2.8.2 Sprinkler Pressure (Waterflow) Alarm Switch

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches, and a 13 mm (1/2 inch) NPT male pipe thread. The switch shall have a maximum service pressure rating of 1207 kPa (175 psi). There shall be two SPDT (Form C) contacts factory adjusted to operate at 28 to 55 kPa (4 to 8 psi). The switch shall be capable of being mounted in any position in the alarm line trim piping of the alarm check valve.

2.8.3 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.9 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting or flush type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass or chromium plated finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963.

2.10 SPRINKLERS

Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed coverage limitations. Temperature classification shall be as indicated on the drawings. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Extended coverage sprinklers shall not be used.

2.10.1 Concealed Sprinkler

Concealed sprinkler shall be chrome-plated, stainless steel, white polyester, quick-response type and shall have a nominal 13 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice.

2.10.2 Recessed Sprinkler

Recessed sprinkler shall be chrome-plated, stainless steel, white polyester, quick-response type and shall have a nominal 13 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice.

2.10.3 Flush Sprinkler

Flush sprinkler shall be chrome-plated, stainless steel, white polyester, quick-response type and shall have a nominal 13 mm (1/2 inch) or 13.5 mm

(17/32 inch) orifice.

2.10.4 Pendent Sprinkler

Pendent sprinkler shall be of the fusible strut or glass bulb type, recessedor quick-response type with nominal 13 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice. Pendent sprinklers shall have a polished chrome, stainless steel, white polyester finish.

2.10.5 Upright Sprinkler

Upright sprinkler shall be brass, chrome-plated, stainless steel, white polyester, quick-response type and shall have a nominal 13 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice.

2.10.6 Sidewall Sprinkler

Sidewall sprinkler shall have a nominal 13 mm (1/2 inch) orifice. Sidewall sprinkler shall have a brass, polished chrome, stainless steel, white polyester finish. Sidewall sprinkler shall be the quick-response type.

2.10.7 Residential Sprinkler

Residential sprinkler shall be the pendentand sidewall type with nominal 13 mm (1/2 inch) orifice. Residential sprinkler shall have a polished chrome, white polyester finish.

2.10.8 Intermediate Level Rack Sprinkler

Intermediate level rack sprinkler shall be of the upright or pendent type with nominal 13 mm (1/2 inch) orifice and minimum "K" factor of 5.5. The sprinkler shall be equipped with a deflector plate to shield the fusible element from water discharged above it.

2.10.9 Corrosion Resistant Sprinkler

Corrosion resistant sprinkler shall be the upright, pendent type installed in locations as indicated. Corrosion resistant coatings shall be factory-applied by the sprinkler manufacturer.

2.10.10 Dry Sprinkler Assembly

Dry sprinkler assembly shall be of the pendent, upright, sidewall, 45-degree type as indicated. Assembly shall include an integral escutcheon. Maximum length shall not exceed maximum indicated in UL Fire Prot Dir. Sprinklers shall have a polished chrome, polyester coating, or white enamel finish.

2.11 DISINFECTING MATERIALS

2.11.1 Liquid Chlorine

Liquid chlorine shall conform to KS M 1103.

2.12 ACCESSORIES

2.12.1 Sprinkler Cabinet

Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.12.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 20 mm (3/4 inch) and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.12.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.12.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers located as indicated.

2.12.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide by 50 mm high (6 inches wide by 2 inches high) with enamel baked finish on minimum 1.214 mm (18 gauge) steel or 0.6 mm (0.024 inch) aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain," "auxiliary drain," "inspector's test," "alarm test," "alarm line," and similar wording as required to identify operational components.

2.13 FIRE HOSE REEL ASSEMBLY

Assembly shall include nozzle, fire hose, reel, 40 mm (1-1/2 inch) valve, and bracket suitable for wall mounting. The assembly shall be semi-automatic type complete with Underwriters clip which permits controlled one-man operation whereby control valve can be opened, hose unreeled and clip released by pulling on hose. Valve shall be non-rising stem, all bronze, angle type with 40 mm (1-1/2 inch) American National Standard Fire Hose Screw Thread (NH) male outlet in accordance with NFPA 1963. Reel shall be of steel construction with red enamel finish and shall be equipped with 30 m (100 feet) of 40 mm (1-1/2 inch) rubber lined fire hose. Nozzle shall be of the industrial combination fog-straight stream type with shutoff. Components of the assembly shall be listed in UL Fire Prot Dir.

2.14 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure gauge test ports and

OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of between 1034 and 1207 kPa (150 and 175 psi). The maximum pressure loss shall be 40 kPa (6 psi) at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow prevention assembly valves.

PART 3 EXECUTION

3.1 FIELD MEASUREMENTS

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of NFPA 13, NFPA 24 and publications referenced therein. Installation of in-rack sprinklers shall comply with applicable provisions of NFPA 13.

3.3 INSPECTION BY FIRE PROTECTION SPECIALIST

Prior to ceiling installation and concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports. The Fire Protection Specialist shall: 1) inspect the sprinkler system periodically during the installation to assure that the sprinkler system is being provided and installed in accordance with the contract requirements, 2) witness the preliminary and final tests, and sign the test results, 3) after completion of the system inspections and a successful final test, certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 ABOVEGROUND PIPING INSTALLATION

3.4.1 Protection of Piping Against Earthquake Damage

Seismically protect the system piping against damage from earthquakes. This requirement is not subject to determination under NFPA 13. Install the seismic protection of the system piping in accordance with UFC 3-310-04, NFPA 13, and Annex A. Include the required features identified therein that are applicable to the specific piping system.

3.4.2 Piping in Exposed Areas

Install exposed piping without diminishing exit access widths, corridors or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.4.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings.

Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.4.4 Pendent Sprinklers

Drop nipples to pendent sprinklers shall consist of minimum 25 mm (1 inch) pipe with a reducing coupling into which the sprinkler shall be threaded. Hangers shall be provided on arm-overs to drop nipples supplying pendent sprinklers when the arm-over exceeds 300 mm (12 inches) for steel pipe or 150 mm (6 inches) for copper tubing. Where sprinklers are installed below suspended or dropped ceilings, drop nipples shall be cut such that sprinkler ceiling plates or escutcheons are of a uniform depth throughout the finished space. The outlet of the reducing coupling shall not extend more than 25 mm (1 inch) below the underside of the ceiling. On pendent sprinklers installed below suspended or dropped ceilings, the distance from the sprinkler deflector to the underside of the ceiling shall not exceed 100 mm (4 inches). Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid.

3.4.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm (30 inches) in length shall be individually supported.

3.4.6 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings, fittings and grooving tools shall be products of the same manufacturer. For copper tubing, pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.4.7 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 13 mm (1/2 inch).

3.4.8 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07 84 00 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.4.9 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm (1 inch) pipe connected to the remote branch line at the riser as a combination test and drain valve; a test valve located approximately 2 m (7 feet) above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test." The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.4.11 Drains

Main drain piping shall be provided to discharge at a safe point outside the building or at the location indicated. Auxiliary drains shall be provided as required by NFPA 13.

3.4.12 Installation of Fire Department Connection

Connection shall be mounted on the exterior wall approximately 900 mm (3 feet) above finished grade or adjacent to and on the sprinkler system side of the backflow preventer. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.4.13 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.5 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be 900 mm (3 feet). The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm (5 feet) outside the building walls shall meet the requirements of Section 33 11 00 WATER DISTRIBUTION.

3.6 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 31 00 00 EARTHWORK.

3.7 ELECTRICAL WORK

Except as modified herein, electric equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Alarm signal wiring connected to the building fire alarm control system shall be in accordance with Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. All wiring for supervisory and alarm circuits shall be #14, #16 AWG solid copper installed in metallic tubing or conduit. Wiring color code shall remain uniform throughout the system.

3.8 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.9 PRELIMINARY TESTS

The system, including the underground water mains, and the aboveground piping and system components, shall be tested to assure that equipment and components function as intended. Submit proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests and proposed date and time to begin the preliminary tests. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, submit one hard copy & one digital copy (.pdf - text searchable) of the completed Preliminary Test Report, no later than 7 days after the completion of the Tests. The Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

3.9.1 Underground Piping

3.9.1.1 Flushing

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less that the calculated maximum water demand rate of the system.

3.9.1.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 2 L (2 quarts) per hour per 100 gaskets or joints, regardless of pipe diameter.

3.9.2 Aboveground Piping

3.9.2.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa (200 psi) or 350 kPa (50 psi) in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.9.2.2 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. Provide all equipment and instruments necessary to conduct a complete forward flow test, including 65 mm (2.5 inch) diameter hoses, playpipe nozzles, calibrated pressure gauges, pitot tube gauge, plus all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. Provide a metal placard on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.9.3 Testing of Alarm Devices

Each alarm switch shall be tested by flowing water through the inspector's test connection. Each water-operated alarm devices shall be tested to verify proper operation. The connecting circuit to the building fire alarm system and to the base-wide fire report system shall be inspected and tested.

3.9.4 Main Drain Flow Test

Following flushing of the underground piping, a main drain test shall be made to verify the adequacy of the water supply. Static and residual pressures shall be recorded on the certificate specified in paragraph SUBMITTALS. In addition, a main drain test shall be conducted each time after a main control valve is shut and opened.

3.10 FINAL ACCEPTANCE TEST

Begin the Final Acceptance Test only when the Preliminary Test Report has been approved. Submit proposed procedures and notification for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests, and proposed date and time to begin the Test, submitted with the procedures. Notification shall include a copy of the Contractor's Material & Test Certificates. The Fire Protection Specialist shall conduct the Final Acceptance Test and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. Submit as-built drawings, no later than 14 days after completion of Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. In addition, the representative shall have available copies of as-built drawings and certificates of tests previously conducted. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received. Submit one hard copy & one digital copy (.pdf - text searchable) of the completed Final Acceptance Test Report no later than 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

3.11 ONSITE TRAINING

The Fire Protection Specialist shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit proposed schedule at least 14 days prior to the start of related training. Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete and after the Final Acceptance Test. Submit one hard copy and one digital copy (.pdf - text searchable) of Operating and Maintenance Manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour on-site response to a service call on an emergency basis. The Onsite Training shall cover all of the items contained in the approved manuals.

-- End of Section --

SECTION 21 13 17.00 10

DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION
05/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1015	(2009) Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.9	(2012) Standard for Factory-Made Wrought

	Steel Buttwelding Fittings
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A795/A795M	(2013) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM F436	(2011) Hardened Steel Washers
ASTM F436M	(2011) Hardened Steel Washers (Metric)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code
NFPA 13	(2013; TIA 10-1; TIA 11-2; ERTA 2014; TIA 14-3) Standard for the Installation of Sprinkler Systems
NFPA 13D	(2013) Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
NFPA 13R	(2013) Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height
NFPA 1963	(2014) Standard for Fire Hose Connections
NFPA 24	(2013) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2010) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Water Based Systems Layout

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir	(2012) Building Materials Directory
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1002	(2001) Hexagon Head Bolts and Hexagon Head Screws
KS B 1004	(2012) Square Head Bolts
KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 4308	(2012) Ductile Iron Fittings
KS D 4311	(2010) Ductile Iron Pipes
KS D 4316	(2012) Mortar Lining of Ductile Iron Pipes & Fittings
KS M 1103	(2008) Liquid Chlorine

1.2 SYSTEM DESCRIPTION

a. Furnish piping offsets, fittings, and any other accessories as required to provide a complete installation and to eliminate interference with other construction. Install sprinkler over and under ducts, piping and platforms when such equipment can negatively affect or disrupt the sprinkler discharge pattern and coverage.

b. Provide dry pipe sprinkler system in areas indicated on the drawings. The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, design and install the system in accordance with NFPA 13. Pipe sizes, which are not indicated on the drawings, shall be determined by hydraulic calculation. Gridded systems shall not be used.

c. Design any portions of the sprinkler system that are not indicated on the drawings or are not specified herein, including locating sprinklers, piping, and equipment, and size piping and equipment. Base the design of the sprinkler system on hydraulic calculations, and the other provisions specified herein.

1.2.1 Hydraulic Design

Hydraulically design the system to discharge a minimum density over the hydraulically most demanding area in compliance with NFPA 13. Provide hydraulic calculations in accordance with the Area\Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s (20 ft/s).

1.2.1.1 Hose Demand

Add an allowance for exterior hose streams to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building. An allowance for interior hose stations shall also be added to the sprinkler system demand.

1.2.1.2 Basis for Calculations

Base the design of the system upon water supply data indicated on drawings. Base hydraulic calculations upon the Hazen-Williams formula with a "C" value of 120 for galvanized steel piping, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping. If a fire pump is required, hydraulic calculations shall be based on operation of the fire pump(s) provided in Section 21 30 00 FIRE PUMPS.

a. Submit Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments. Outline hydraulic calculations as in NFPA 13, except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall substantiate that the design area used in the calculations is the most demanding hydraulically.

b. Plot water supply curves and system requirements on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. Provide a summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows.

Indicate elevations of hydraulic reference points (nodes). Documentation shall identify each pipe individually and the nodes connected thereto. Indicate for each pipe the diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient.

1.2.2 Sprinkler Coverage

Uniformly space sprinklers on branch lines. In buildings protected by automatic sprinklers, provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms, boiler rooms, switchgear rooms, transformer rooms, and other electrical and mechanical spaces. Coverage per sprinkler shall be in accordance with NFPA 13, but not exceeding 9 square m (100 square feet) for extra hazard occupancies, 12 square m (130 square feet) for ordinary hazard occupancies, and 21 square m (225 square feet) for light hazard occupancies. Exceptions are as follows:

a. Facilities that are designed in accordance with NFPA 13R and NFPA 13D.

b. Sprinklers may be omitted from small rooms which are exempted for specific occupancies in accordance with NFPA 101.

1.2.3 System Volume Limitations

Where the volume of any individual system piping volume exceeds 1890 L (500 gallons), provide the dry pipe valve with a quick-opening device. The maximum system capacity controlled by one dry pipe valve shall not exceed 2800 L (750 gallons). Indicate the calculated volume of each system on the Sprinkler System Shop Drawings.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

One hard copy and one digital copy of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. The drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance.

As-Built Drawings

One hard copy and one digital copy of as-built shop drawings, no later than 14 days after completion of the Final Tests. The Sprinkler System As-Built Drawings shall be updated to reflect as-built conditions after all related work is completed. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-03 Product Data

List of Submittals; G

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Materials and Equipment; G

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Spare Parts

Spare parts data shall be included for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Onsite Training; G

Proposed On-site Training schedule, at least 14 days prior to the start of related training.

SD-05 Design Data

Sway Bracing; G

For systems that are required to be protected against damage from earthquakes, load calculations shall be provided for sizing of sway bracing.

Hydraulic Calculations; G

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

SD-06 Test Reports

Preliminary Tests; G

Proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests, also proposed date and time to begin the tests, with the Preliminary Tests Procedures.

One hard copy and one digital copy (.pdf - text searchable) of the completed Preliminary Test Report, no later that 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

Final Acceptance Test; G

Submit proposed procedures and notification for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests and proposed date and time to begin Final Acceptance Test, with the Final Acceptance Test Procedures. Notification shall include a copy of the Contractor's Material & Test Certificates.

One hard copy and one digital copy (.pdf - text searchable) of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Fire Protection Specialist; G

The name and documentation of certification of the proposed Fire Protection Specialist, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations.

Installer Qualifications; G

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

Inspection by Fire Protection Specialist; G

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

One hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour on-site response to a service call on an emergency basis.

1.4 QUALITY ASSURANCE

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

1.4.1 Fire Protection Specialist

Perform the work specified in this section under the supervision of and certified by the Fire Protection Specialist (FPS) who is a registered professional engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES), is in a related engineering discipline with a minimum of 5 years experience dedicated to fire protection engineering that can be verified with documentation, or who is certified as a Level III or IV Technician by the National Institute for Certification in Engineering Technologies (NICET) in the Water Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. Submit the name and documentation of certification of the proposed FPS, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system shop drawings and hydraulic calculations. The FPS shall prepare and submit a list of submittals related to Fire Protection from the Contract Submittal Register that verify the successful installation of the sprinkler systems(s), no later than 7 days after the approval of the FPS. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the FPS when submitted to the Government. The FPS shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.2 Installer Qualifications

Work specified in this section shall be performed by the Sprinkler System Installer. Submit the name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the FPS Qualifications. The Installer shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.3 Shop Drawings

Submit one hard copy and one digital copy of the Sprinkler System Drawings no later than 21 days prior to the start of sprinkler system installation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. The drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance; update the shop drawings to reflect as-built conditions after all related work is completed. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 (1/8" = 1'-0") which clearly show locations of sprinklers, risers, pipe hangers, seismic separation assemblies, sway bracing, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Indicate each type of fitting used and the locations of bushings, reducing couplings, and welded joints..

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; air supply system and piping; pipe hanger; sway bracing for earthquake protection, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring.

1.5 DELIVERY, STORAGE, AND HANDLING

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.6 EXTRA MATERIALS

The Contractor shall submit spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. Highlight the data to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, provide a complete equipment list that includes equipment description, model number and quantity.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE.

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe

Piping from a point 150 mm (6 inches) above the floor to a point 1500 mm (5 feet) outside the building wall or the point of connection to the existing water mains shall be ductile iron with a rated working pressure of 1034 or 1207 kPa (150 or 175 psi) conforming to AWWA C151/A21.51 or KS D 4311, with cement mortar lining conforming to AWWA C104/A21.4 or KS D 4316. Piping more than 1500 mm (5 feet) outside the building walls shall comply with Section 33 11 00 WATER DISTRIBUTION.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to AWWA C110/A21.10 or KS D 4308. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to AWWA C111/A21.11 or KS D 4308..

2.4.3 Gate Valve and Indicator Post

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM APP GUIDE.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Steel Pipe

Except as modified herein, steel pipe shall be black as permitted by NFPA 13 and shall conform to applicable provisions of ASTM A795/A795M, ASTM A53/A53M, ASTM A135/A135M or KS D 3562. Pipe in which threads or grooves are cut or rolled formed shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and ASTM designation.

2.5.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be galvanized steel conforming to ASME B16.9 or ASME B16.11 or cast iron conforming to ASME B16.4, steel conforming to ASME B16.9 or ASME B16.11, or malleable iron conforming to ASME B16.3. Fittings that sprinklers, drop nipples or riser nipples (sprigs) are screwed into shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer; segmented welded fittings shall not be used. Fitting and coupling houses shall be malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12. Gaskets shall be of silicon compound and approved for dry fire protection systems. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.5.4 Flanges

Flanges shall conform to NFPA 13 and ASME B16.1. Gaskets shall be non-asbestos compressed material in accordance with ASME B16.21, 1.6 mm (1/16 inch) thick, and full face or self-centering flat ring type.

2.5.4.1 Bolts

Bolts shall be ASME B18.2.1 and ASTM A449, Type 1 or KS B 1002, Strength Class 9.8 and shall extend no less than three full threads beyond the nut with bolts tightened to the required torque. Bolts shall be squarehead conforming to ASME B18.2.1 or KS B 1004

2.5.4.2 Nuts

Nuts shall be hexagon type conforming to ASME B18.2.2 or ASTM A193/A193M, Grade 5 or ASTM A563M, Grade C3 or DH3 or KS B 1012.

2.5.4.3 Washers

Washers shall meet the requirements of ASTM F436M (ASTM F436). Flat circular washers shall be provided under all bolt heads and nuts.

2.5.5 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM APP GUIDE and of the type suitable for the application, construction, and pipe type and size to be supported.

2.5.6 Valves

2.5.6.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM APP GUIDE.

2.5.6.2 Check Valve

Check valve 50 mm (2 inches) and larger shall be listed in UL Bld Mat Dir or FM APP GUIDE. Check valves 100 mm (4 inches) and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.6 DRY PIPE VALVE ASSEMBLY

The dry pipe valve shall be a latching differential type listed in UL Fire Prot Dir or FM APP GUIDE and shall be complete with trim piping, valves, fittings, pressure gauges, priming water fill cup, velocity drip check, drip cup, and other ancillary components as required for proper operation. The assembly shall include a quick-opening device by the same manufacturer as the dry pipe valve for systems over 1890 L (500 gallons) in capacity.

2.7 SUPERVISORY AIR SYSTEM

Provide an air supply system in accordance with NFPA 13. The connection pipe from the air compressor shall not be less than 13 mm 1/2 inch in diameter and shall enter the system above the priming water level of the dry pipe valve. Install a check valve in the system supply air piping from the compressor. A shutoff valve of the renewable disc type shall be installed upstream of this check valve. The air supply system shall be sized to pressurize the sprinkler system to 275 kPa (40 psi) within 20 minutes.

2.7.1 Air Compressor

Compressor shall be single stage oil-free type, air-cooled, electric-motor driven, equipped with a check valve, shutoff valve and pressure switch for automatic starting and stopping. Pressure switch shall be factory set to start the compressor at 200 kPa (30 psi) and stop it at 300 kPa (40 psi). A safety relief valve, set to operate at 450 kPa (65 psi), shall be provided.

2.7.2 Air Pressure Maintenance Device

Device shall be a pressure regulator that automatically reduces supply air to provide the pressure required to be maintained in the piping system. The device shall have a cast bronze body and valve housing complete with diaphragm assembly, spring, filter, ball check to prevent backflow, 1.6 mm (1/16 inch) restriction to prevent rapid pressurization of the system, and adjustment screw. The device shall be capable of reducing an inlet pressure of up to 680 kPa (100 psig) to a fixed outlet pressure adjustable to 70 kPa (10 psig).

2.7.3 Air Supply Piping System

System shall be configured so that each dry pipe system is equipped with a separate pressure maintenance device, air compressor, shutoff valve, bypass valve and pressure gauge. Piping shall be galvanized steel in accordance with ASTM A795/A795M, ASTM A53/A53M or KS D 3562, schedule 40.

2.7.4 Low Air Pressure Alarm Device

Each dry pipe valve trim shall be provided with a local alarm device consisting of a metal enclosure containing an alarm horn or bell, silence switch, green power-on light, red low-air alarm light and amber trouble light. Activate the alarm device by the low air pressure switch. Upon reduction of sprinkler system pressure to approximately 70 kPa (10 psig) above the dry valve trip point pressure, the low air pressure switch shall actuate the audible alarm device and a red low-air alarm light. Restoration of system pressure shall cause the low-air alarm light to be extinguished and the audible alarm to be silenced. An alarm silence switch shall be provided to silence the audible alarm. An amber trouble light shall be provided which will illuminate upon operation of the silence switch and shall be extinguished upon return to its normal position.

2.8 WATERFLOW ALARM

Electrically operated, exterior-mounted, waterflow alarm bell shall be provided and installed in accordance with NFPA 13. Waterflow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel(FACP) in accordance with Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. Or, if indicated on contract drawings, mechanically operated, exterior-mounted, water motor alarm assembly shall be provided and installed in accordance with NFPA 13. Water motor alarm assembly shall include a body housing, impeller or pelton wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 19 mm (3/4 inch) valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and outside surfaces.

2.9 ALARM INITIATING AND SUPERVISORY DEVICES

2.9.1 Sprinkler Pressure (Waterflow) Alarm Switch

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches and a 13 mm (1/2 inch) NPT male pipe thread. The switch shall have a maximum service pressure rating of 1207 kPa (175 psi). There shall be two SPDT (Form C) contacts factory adjusted to operate at 28 to 55 kPa (4 to 8 psi). The switch shall be capable of being mounted in any position in the alarm line trim piping of the dry pipe valve.

2.9.2 Low Air Pressure Supervisory Switch

The pressure switch shall supervise the air pressure in system and shall be set to activate at 70 kPa (10 psi) above the dry pipe valve trip point pressure. The switch shall have an adjustable range between 35 and 500 kPa (5 and 80 psi). The switch shall have screw terminal connection and shall be capable of being wired for normally open or normally closed circuit.

2.9.3 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.10 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting or flush type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass or chromium plated finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) in accordance with NFPA 1963.

2.11 SPRINKLERS

Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed coverage limitations. Areas where sprinklers are connected to or are a part of the dry pipe system shall be considered unheated and subject to freezing. Temperature classification shall be as indicatedon drawings. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Extended coverage sprinklers shall not be used.

2.11.1 Pendent Sprinkler

Pendent sprinkler heads shall be the dry pendent type, unless otherwise indicated. Pendent sprinkler shall be of the fusible strut or glass bulb type, recessed or quick-response type with nominal 13 mm (1/2 inch) 13.5 mm (17/32 inch) orifice. Pendent sprinklers shall have a polished chrome, stainless steel, or white polyester finish. Assembly shall include an integral escutcheon. Maximum length shall not exceed the maximum length indicated in UL Fire Prot Dir.

2.11.2 Upright Sprinkler

Upright sprinkler shall be brass, chrome-plated, stainless steel, white polyester, quick-response type and shall have a nominal 13 mm (1/2 inch) 13.5 mm (17/32 inch) orifice.

2.11.3 Corrosion Resistant Sprinkler

Corrosion resistant sprinkler shall be upright, pendent type installed in locations as indicated. Corrosion resistant coatings shall be factory-applied by the sprinkler manufacturer.

2.12 DISINFECTING MATERIALS

2.12.1 Liquid Chlorine

Liquid chlorine shall conform to KS M 1103.

2.13 ACCESSORIES

2.13.1 Sprinkler Cabinet

Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.13.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 19 mm (3/4 inch) and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.13.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.13.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers located as indicated.

2.13.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide by 50 mm high (6 inches wide by 2 inches high) with enamel baked finish on minimum 1.214 mm (18 gauge) steel or 0.6 mm (0.024 inch) aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain," "auxiliary drain," "inspector's test," "alarm test," "alarm line," and similar wording as required to identify operational components.

2.14 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure gauge test ports and OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of 1034 or 1207 kPa (150 or 175 psi). The maximum pressure loss shall be 40 kPa (6 psi) at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow prevention assembly valves.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 31 00 00 EARTHWORK.

3.3 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of

NFPA 13, NFPA 24 and publications referenced therein.

3.4 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the sprinkler system periodically during the installation to assure that the sprinkler system installed in accordance with the contract requirements. The Fire Protection Specialist shall witness the preliminary and final tests, and shall sign the test results. The Fire Protection Specialist, after completion of the system inspections and a successful final test, shall certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered. Submit, concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

3.5 ABOVEGROUND PIPING INSTALLATION

3.5.1 Protection of Piping Against Earthquake Damage

Seismically protect the system piping against damage from earthquakes. This requirement is not subject to determination under NFPA 13. Install the seismic protection of the system piping, including sway bracing as required, in accordance with UFC 3-13-04, NFPA 13 and Annex A. Submit load calculations for sizing of sway bracing, for systems that are required to be protected against damage from earthquakes. Include the required features identified therein that are applicable to the specific piping system.

3.5.2 Piping in Exposed Areas

Exposed piping shall be installed so as not diminish exit access widths, corridors, or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.5.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings. Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.5.4 Pendent Sprinklers Locations

Sprinklers installed in the pendent position shall be of the listed dry pendent type, unless otherwise indicated. Dry pendent sprinklers shall be of the required length to permit the sprinkler to be threaded directly into a branch line tee. Hangers shall be provided on arm-overs to drop nipples supplying pendent sprinklers when the arm-over exceeds 300 mm (12 inches) for steel pipe or 150 mm (6 inches) for copper tubing. Dry pendent sprinkler assemblies shall be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.5.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm (30 inches) in length shall be individually supported.

3.5.6 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings and fittings shall be from the same manufacturer. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.5.7 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 13 mm (1/2 inch).

3.5.8 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve in accordance with NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07 84 00 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.5.9 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.5.10 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm (1 inch) pipe connected to the remote branch line at the riser as a combination test and drain valve; a test valve located approximately 2 m (7 fee)t above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test." The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.5.11 Drains

Provide main drain piping to discharge at a safe point outside the building or at the location indicated. Auxiliary drains shall be provided as indicated and as required by NFPA 13. When the capacity of trapped sections of pipe is less than 11 L (3 gallons), the auxiliary drain shall consist of a valve not smaller than 15 mm (1/2 inch) and a plug or nipple and cap. When the capacity of trapped sections of piping is more than 11 L (3 gallons), the auxiliary drain shall consist of two 25 mm (1 inch) valves and one 50 x 300 mm (2 x 12 inch) condensate nipple or equivalent, located in an accessible location. Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be a minimum of 25 mm (1 inch) in diameter. Tie-in drain lines shall be pitched a minimum of 15 mm per 3 m (1/2 inch per 10 feet).

3.5.12 Installation of Fire Department Connection

Connection shall be mounted on the exterior wall approximately 900 mm (3 feet) above finished grade or adjacent to and on the sprinkler system side of the backflow preventer. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.5.13 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.6 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be 900 mm (3 feet). The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm (5 feet) outside the building walls shall meet the requirements of Section 33 11 00 WATER DISTRIBUTION.

3.7 ELECTRICAL WORK

Except as modified herein, electric equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Alarm signal wiring connected to the building fire alarm control system shall be in accordance with Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. All wiring for supervisory and alarm circuits shall be #14, #16 AWG solid copper installed in metallic tubing or conduit. Wiring color code shall remain uniform throughout the system.

3.8 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.9 PRELIMINARY TESTS

The system, including the underground water mains and the aboveground piping and system components, shall be tested to assure that equipment and components function as intended. Submit proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests, also proposed date and time to begin the tests, with the Preliminary Tests Procedures. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, submit complete certificates as specified and one hard copy and one digital copy (.pdf - text searchable) of the completed Preliminary Tests Reports, no later than 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

3.9.1 Underground Piping

3.9.1.1 Flushing

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less that the calculated maximum water demand rate of the system.

3.9.1.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 2 L (2 quarts) per hour per 100 gaskets or joints, regardless of pipe diameter.

3.9.2 Aboveground Piping

3.9.2.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa (200 psi) or 350 kPa (50 psi) in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.9.2.2 Air Pressure Test

As specified in NFPA 13, an air pressure leakage test at 350 kPa (50 psi) shall be conducted for 24 hours. There shall be no drop in gauge pressure in excess of 10 kPa (1.5 psi) for the 24 hours. This air pressure test is in addition to the required hydrostatic test.

3.9.2.3 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. Provide all equipment and instruments necessary to conduct a complete forward flow test, including 65 mm (2.5 inch) diameter hoses, playpipe nozzles, calibrated pressure gauges, and pitot tube gauge. Provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. A metal placard shall be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.9.3 Testing of Alarm Devices

Each alarm initiating device, including pressure alarm switch, low air pressure switch, valve supervisory switch, and electrically-operated switch shall be tested for proper operation. Water motor alarm shall be tested. The connecting circuit to the building fire alarm system and to the base-wide fire report system shall be inspected and tested.

3.9.4 Trip Tests of Dry Pipe Valves

Each dry pipe valve shall be trip-tested by reducing normal system air pressure through operation the inspector's test connection. Systems equipped with quick opening devices shall be first tested without the operation of the quick opening device and then with it in operation. Test results will be witnessed and recorded. Test results shall include the number of seconds elapsed between the time the test valve is opened and tripping of the dry valve; trip-point air pressure of the dry pipe valve; water pressure prior to valve tripping; and number of seconds elapsed between time the inspector's test valve is opened and water reaches the orifice.

3.9.5 Main Drain Flow Test

Following flushing of the underground piping, a main drain test shall be made to verify the adequacy of the water supply. Static and residual pressures shall be recorded on the certificate specified in paragraph SUBMITTALS. In addition, a main drain test shall be conducted each time after a main control valve is shut and opened.

3.10 FINAL ACCEPTANCE TEST

Final Acceptance Test shall begin only when the Preliminary Test Report has been approved. The Fire Protection Specialist shall conduct the Final Acceptance Test and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. Submit proposed procedures and notification for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests and proposed date and time to begin Final Acceptance Test, with the Final Acceptance Test Procedures. Notification shall include a copy of the Contractor's Material & Test Certificates. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. Each system shall be completely drained after each trip test. The system air supply system shall be tested to verify that system pressure is restored in the specified time. In addition, the Fire Protection Specialist shall have available copies of as-built drawings and certificates of tests previously conducted. Submit one hard copy and one digital copy of as-built shop drawings, no later than 14 days after completion of the Final Tests. The Sprinkler System As-Built Drawings shall be updated to reflect as-built conditions after all related work is completed. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received. After the system has been tested and drained, the system shall be drained periodically for at least 2 weeks until it can be assured that water from the system has been removed. Submit one hard copy and one digital copy (.pdf - text searchable) of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

3.11 ONSITE TRAINING

The Fire Protection Specialist and Manufacturer's Representative shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit Proposed Onsite Training schedule, at least 14 days prior to the start of related training. Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete and after the Final Acceptance Test. The Onsite Training shall cover all of the items contained in the approved Operating and Maintenance Instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour on-site response to a service call on an emergency basis..

-- End of Section --

SECTION 21 13 18.00 10

PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION
05/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1015	(2009) Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.9	(2012) Standard for Factory-Made Wrought

	Steel Buttwelding Fittings
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A795/A795M	(2013) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM F436	(2011) Hardened Steel Washers
ASTM F436M	(2011) Hardened Steel Washers (Metric)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code
NFPA 13	(2013; TIA 10-1; TIA 11-2; ERTA 2014; TIA 14-3) Standard for the Installation of Sprinkler Systems
NFPA 13D	(2013) Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
NFPA 13R	(2013) Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height
NFPA 1963	(2014) Standard for Fire Hose Connections
NFPA 24	(2013) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2010) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Water Based Systems Layout

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir	(2012) Building Materials Directory
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 4311	(2010) Ductile Iron Pipes
KS D 4316	(2012) Mortar Lining of Ductile Iron Pipes & Fittings
KS M 1103	(2008) Liquid Chlorine

1.2 SYSTEM DESCRIPTION

a. Furnish piping offsets, fittings, and any other accessories as required to provide a complete installation and to eliminate interference with other construction. Install sprinkler over and under ducts, piping and platforms when such equipment can negatively affect or disrupt the sprinkler discharge pattern and coverage.

b. Provide preaction or deluge sprinkler system(s) in areas indicated on the drawings. The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, the system shall meet the requirements of NFPA 13 and NFPA 72. The sprinkler system shall be a single interlocked system that requires the actuation of an alarm initiating device to open the water control (deluge) valve.

c. Design any portions of the sprinkler system that are not indicated on the drawings or are not specified herein, including locating sprinklers, piping, and equipment, and size piping and equipment. Determine pipe sizes which are not indicated on the drawings by hydraulic calculations.

1.2.1 Hydraulic Design

Hydraulically design the system to discharge a minimum density over the hydraulically most demanding 280 square m (3,000 square feet) of floor area. The minimum pipe size for branch lines in gridded systems shall be 32 mm (1-1/4 inch). Hydraulic calculations shall be in accordance with the Area/Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s (20 ft/s).

1.2.1.1 Hose Demand

Add an allowance for exterior hose streams to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building or at the point of connection to the existing water system. An allowance for interior hose stations shall also be added to the sprinkler system demand.

1.2.1.2 Basis for Calculations

Base the design of the system upon water supply data indicated on drawings. Base hydraulic calculations upon the Hazen-Williams formula with a "C" value of 120 for galvanized steel piping, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping.

If a fire pump is required, hydraulic calculations shall be based on operation of the fire pump(s) provided in Section 21 30 00 FIRE PUMPS.

a. Outline hydraulic calculations as in NFPA 13, except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Submit hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall substantiate that the design area used in the calculations is the most demanding hydraulically.

b. Plot water supply curves and system requirements on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. Provide a summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows. Indicate elevations of hydraulic reference points (nodes). Documentation shall identify each pipe individually and the nodes connected thereto. Indicate for each pipe the diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient.

c. For gridded systems, calculations shall show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. Also for gridded systems, include a flow diagram indicating the quantity and direction of flows. A drawing showing hydraulic reference points (nodes) and pipe designations used in the calculations shall be included and shall be independent of shop drawings.

1.2.2 Sprinkler Coverage

Uniformly space sprinklers on branch lines. In buildings protected by automatic sprinklers, provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms, boiler rooms, switchgear rooms, transformer rooms, and other electrical and mechanical spaces. Coverage per sprinkler shall be in accordance with NFPA 13, but shall not exceed 9 square m (100 square feet) for extra hazard occupancies, 12 square m (130 square feet) for ordinary hazard occupancies, and 21 square m (225 square feet) for light hazard occupancies. Exceptions are as follows:

a. Facilities that are designed in accordance with NFPA 13R and NFPA 13D.

b. Sprinklers may be omitted from small rooms which are exempted for specific occupancies in accordance with NFPA 101.

1.2.3 Control System

The control system shall meet the requirements of NFPA 72. The control panel shall be listed in UL Fire Prot Dir or FM APP GUIDE for "Releasing Device Service". The control panel and the solenoid valve that activates the water control valves shall be compatible with each other. Compatibility shall be in accordance with specific UL listing or FM approval of the control equipment.

1.2.3.1 Power Supply

Provide the primary operating power from two single-phase 120 VAC circuits. Transfer from normal to backup power and restoration from backup to normal power shall be fully automatic and shall not initiate a false alarm. Loss of primary power shall not prevent actuation of the respective automatic water control valve upon activation of any alarm initiating device. Provide backup power through use of rechargeable, sealed, lead calcium storage batteries.

1.2.3.2 Circuit Requirements

Connect alarm initiating devices to initiating device circuits (IDC), Style D or to signal line circuits (SLC), Style 6, in accordance with NFPA 72. Alarm notification or indicating appliances shall be connected to indicating appliance circuit (IAC), Style W or X in accordance with NFPA 72. Provide a separate circuit for actuation of each individual automatic water control valve. Fully supervise the circuits that actuate the water control valves so that the occurrence of a single open or a single ground fault condition in the interconnecting conductors will be indicated at the control panel.

1.2.4 System Operational Features

Include in the system a heat detection system, manual actuation stations, supervisory and alarm switches, alarm notification appliances, control panel and associated equipment. Provide preaction sprinkler system piping with supervisory air pressure not to exceed 210 kPa (30 psig).

1.2.4.1 System Actuation

Activation of any single heat detector or 2 heat detectors or a single manual actuation station shall actuate alarm zone circuits of the control panel that, in turn, shall actuate the corresponding automatic water control valve. Actuation of the automatic water control valve shall cause water to fill the preaction system piping and be discharged from fused sprinklers or discharge from the open sprinklers of the deluge system.

1.2.4.2 Alarm Functions

Activation of any heat detector or sprinkler pressure alarm switch or manual actuation station shall cause the illumination of the respective zone annunciator, and activation of the building fire alarm system, transmission of the alarm to the base-wide fire reporting system. Valve tamper alarm shall be monitored by the system control panel and transmitted to the building fire alarm system as a trouble alarm.

1.2.4.3 Supervisory Functions

The reduction of supervisory air pressure within the sprinkler system piping to less than 70 kPa (10 psi) or the occurrence of a single open or a single ground fault in any alarm initiating device circuit, in the automatic water control valve actuation circuit, in any alarm indicating appliance circuit or in other electrically supervised circuit shall cause the individually labeled control panel trouble light to be illuminated, the audible trouble alarm to be activated, and a trouble alarm to be transmitted to the building fire alarm control panel and to base-wide fire reporting system.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

One hard copy & one digital copy of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

As-Built Drawings

As-built shop drawings, no later than 14 days after completion of Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-03 Product Data

List of Submittals; G

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Materials and Equipment; G

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Spare Parts

Spare parts data shall be included for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Onsite Training; G

Proposed On-site Training schedule, at least 14 days prior to the start of related training.

SD-05 Design Data

Sway Bracing; G

For systems that are required to be protected against damage from earthquakes, load calculations shall be provided for sizing of sway bracing.

Hydraulic Calculations; G

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

Storage Batteries; G

Calculations to substantiate the total requirements for supervisory and alarm power. Include ampere-hour requirements for each system component and each control panel component or module, under both normal and alarm conditions. The battery recharging period shall be included with the calculations.

SD-06 Test Reports

Preliminary Tests; G

One hard copy and one digital copy (.pdf - text searchable) of the completed Preliminary Test Report, no later that 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

Final Acceptance Tests; G

One hard copy and one digital copy (.pdf - text searchable) of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Fire Protection Specialist; G

The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations.

Installer Qualifications; G

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

Inspection by Fire Protection Specialist; G

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary, Detection and Control Systems, and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

One hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour on-site response to a service call on an emergency basis.

1.4 QUALITY ASSURANCE

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. Applicable material and installation standards referenced in Appendix A of NFPA 13 and NFPA 24 shall be considered mandatory the same as if such referenced standards were specifically listed in this specification. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. Incorporate all requirements that exceed the minimum requirements of NFPA 13 into the design. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

1.4.1 Fire Protection Specialist

Perform the work specified in this section under the supervision of and certified by the Fire Protection Specialist (FPS) who is a registered professional engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES), is in a related engineering discipline with a minimum of 5 years experience, dedicated to fire protection engineering that can be verified with documentation, or who is certified as a Level III or IV Technician by National Institute for Certification in Engineering Technologies (NICET) in the Water Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7.The FPS shall prepare and submit a list of submittals, related to fire protection, from the Contract Submittal Register that relate to the successful installation of the sprinkler systems(s), no later than 7 days after the approval of the FPS. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the FPS when submitted to the Government. The FPS shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.2 Installer Qualifications

Work specified in this section shall be performed by the Sprinkler System Installer. Submit the name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the FPS Qualifications. The Installer shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.3 Shop Drawings

Submit one hard copy & one digital copy of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. The drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance. Update the Shop Drawings to reflect as-built conditions after all related work is completed. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 (1/8" = 1'-0") which clearly show locations of sprinklers, risers, pipe hangers, seismic separation assemblies, sway bracing, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Indicate each type of fitting used and the locations of bushings, reducing couplings, and welded joints.

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; pipe hanger; sway bracing for earthquake protection, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring.

f. Complete point-to-point wiring diagram of the detection and control system. Indicate the detailed interconnection of control panel modules to the devices, the number and size of conductors in each conduit, and size of conduit. Connection points shall be indicated and coordinated with the terminal identification marked on the devices. Provide complete internal wiring schematic of the control panel and each electrical device. Detailed description of the functions of the control panel and each module shall be provided.

1.5 DELIVERY, STORAGE, AND HANDLING

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.6 EXTRA MATERIALS

The Contractor shall submit spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. Highlight the data to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, provide a complete equipment list that includes equipment description, model number and quantity.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Materials and equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE.

2.4 UNDERGROUND PIPING SYSTEMS

2.4.1 Pipe

Piping from a point 150 mm (6 inches) above the floor to a point 1500 mm (5 feet) outside the building wall or the point of connection to the existing water mains shall be ductile iron with a rated working pressure between 1034 and 1207 kPa (150 and 175 psi) conforming to AWWA C151/A21.51 or KS D 4311, with cement mortar lining conforming to AWWA C104/A21.4 or KS D 4316. Piping more than 1500 mm (5 feet) outside the building walls shall comply with Section 33 11 00 WATER DISTRIBUTION.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to AWWA C110/A21.10. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to AWWA C111/A21.11.

2.4.3 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM APP GUIDE.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Steel Pipe

Except as modified herein, steel pipe shall be black as permitted by NFPA 13 and shall conform to applicable provisions of ASTM A795/A795M, ASTM A53/A53M, ASTM A135/A135M, or KS D 3562. Pipe in which threads or grooves are cut or rolled formed shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and ASTM designation.

2.5.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be cast iron conforming to ASME B16.4, steel conforming to ASME B16.9 or ASME B16.11, or malleable iron conforming to ASME B16.3.. Fittings that sprinklers, drop nipples or riser nipples (sprigs) are screwed into shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer; segmented welded fittings shall not be used. Fitting and coupling houses shall be malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12. Gaskets shall be of silicon compound and approved for dry fire protection systems. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.5.4 Flanges

Flanges shall conform to NFPA 13 and ASME B16.1. Gaskets shall be non-asbestos compressed material in accordance with ASME B16.21, 1.6 mm (1/16 inch) thick, and full face or self-centering flat ring type.

2.5.4.1 Bolts

Bolts shall be ASTM A449, Type 1. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

2.5.4.2 Nuts

Nuts shall be hexagon type conforming to ASME B18.2.2, or ASTM A193/A193M, Grade 5, or ASTM A563M (ASTM A563), Grade C3 or DH3, or KS B 1012.

2.5.4.3 Washers

Washers shall meet the requirements of ASTM F436M(ASTM F436). Flat circular washers shall be provided under all bolt heads and nuts.

2.5.5 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM APP GUIDE and of the type suitable for the application, construction, and pipe type and size to be supported.

2.5.6 Valves

2.5.6.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM APP GUIDE.

2.5.6.2 Check Valves

Check valve 50 mm (2 inches) and larger shall be listed in UL Bld Mat Dir or FM APP GUIDE. Check valves 100 mm (4 inches) and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.6 AUTOMATIC WATER CONTROL VALVE (DELUGE VALVE)

Automatic water control valve (deluge valve) shall be electrically-actuated and rated for a working pressure of 1207 kPa (175 psi). Valve shall be capable of being reset without opening the valve. Electrical solenoid valve used to actuate the water control valve shall be an integral component of the valve or shall be approved for use by the water control valve manufacturer. Solenoid valve shall be rated at 24 volts direct current, and shall be normally closed type that operates when energized. Solenoid valves shall be rated for a maximum pressure differential of 1207 kPa (175 psi). Water control valve shall be equipped with a means to prevent the valve from returning to the closed position until being manually reset. Assembly shall be complete with the valve manufacturer's standard trim piping, drain and test valves, pressure gauges, and other required appurtenances. Include with each assembly an emergency release device for manually tripping the water control valve in the event of a power or other system failure. Device shall be a standard accessory component of the valve manufacturer and shall be labeled as to its function and method of operation. Valves located in hazardous locations shall be approved for the hazard classification of the area where located.

2.7 SUPERVISORY AIR SYSTEM

2.7.1 Air Compressor

Air compressor shall be single stage oil less type, air cooled, electric-motor driven, equipped with a check valve, centrifugal pressure and moisture unloader, pressure switch for automatic starting and stopping. Pressure switch shall be set to start the compressor at 140 kPa (20 psi) and stop it at 200 kPa (30 psi). A safety relief valve, set to operate at 450 kPa (65 psi), shall be provided. The compressor shall be sized to pressurize the system to 200 kPa (30 psi) within 30 minutes.

2.7.2 Air Pressure Maintenance Device

Device shall be a pressure regulator that automatically reduces supply air pressure to the minimum pressure required to be maintained in the piping system. The device shall have a cast bronze body and valve housing complete with diaphragm assembly, spring, filter, ball check to prevent backflow, 1.6 mm (1/16 inch) restriction to prevent rapid pressurization of the system, and adjustment screw. The device shall be capable of reducing maximum inlet pressure of 680 kPa (100 psi) to a fixed outlet pressure adjustable to 70 kPa (10 psi).

2.7.3 Air Supply Piping System

Each preaction system shall be equipped with a separate pressure maintenance device, shutoff valve, bypass valve and pressure gauge. Piping shall be galvanized steel in accordance with ASTM A795/A795M, ASTM A53/A53M, or KS D 3562, Schedule 40.

2.7.4 Low Air Pressure Switch

Each preaction system shall be provided with an air pressure switch connected to the control panel. Upon reduction of supervisory air pressure to approximately 70 kPa (10 psi), the low air pressure switch shall actuate the audible alarm device and a red low-air alarm light on the control panel annunciator.

2.8 WATER MOTOR ALARM ASSEMBLY

Assembly shall include a body housing, impeller wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum20 mm (3/4 inch) galvanized piping shall be provided between the housing and the automatic water control valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized steel and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and on the outside surfaces.

2.9 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting or flush type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass or chromium plated finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) in accordance with NFPA 1963.

2.10 SPRINKLERS

Sprinklers for preaction systems shall be automatic, fusible solder or glass bulb type; sprinklers for deluge systems shall be open type without the fusible element. Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed coverage limitations. Temperature classification shall be as indicated on the drawings. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Extended coverage sprinklers shall not be used.

2.10.1 Pendent Sprinkler

Pendent sprinkler shall be of the fusible strut or glass bulb type, recessed or quick-response type with nominal 13 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice. Pendent sprinklers shall have a polished chrome, stainless steel, white polyester finish.

2.10.2 Upright Sprinkler

Upright sprinkler shall be brass, chrome-plated, stainless steel, white polyester, quick-response type and shall have a nominal 13 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice.

2.10.3 Corrosion Resistant Sprinkler

Corrosion resistant sprinkler shall be the upright, pendent type installed in locations as indicated. Corrosion resistant coatings shall be factory-applied by the sprinkler manufacturer.

2.11 DISINFECTING MATERIALS

2.11.1 Liquid Chlorine

Liquid chlorine shall conform to KS M 1103.

2.12 ACCESSORIES

2.12.1 Sprinkler Cabinet

Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.12.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 19 mm (3/4 inch) and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.12.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.12.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers located as indicated.

2.12.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide by 50 mm high (6 inches wide by 2 inches high) with enamel baked finish on minimum 1.214 mm (18 gauge) steel or 0.6 mm (0.024 inch) aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain," "auxiliary drain," "inspector's test," "alarm test," "alarm line," and similar wording as required to identify operational components.

2.13 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure test gauge ports and OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of between 1034 and 1207 kPa (150 and 175 psi). The maximum pressure loss shall be 40 kPa (6 psi) at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow prevention assembly valves.

2.14 CONTROL PANEL

Panel shall be UL listed or FM approved for "Releasing Device Service" or shall have modules approved for this purpose. Panel shall contain all components and equipment required to provide the specified operational and supervisory functions of the system. House components in a surface or flush-mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly factory assembled and wired unit. Panel shall include integral "power on," "alarm," and "trouble" lamps with annunciation of each alarm, supervisory and trouble signal. The panel shall have prominent rigid plastic or metal identification plates for lamps, zones, controls, meters, fuses, and switches. Nameplates for fuses shall also include ampere rating. Control panel switches shall be within the locked cabinet. Provide a suitable means for testing the working condition and accuracy of the control panel visual indicating devices (meter and lamps). Meters and lamps shall be plainly visible when the cabinet door is closed. Signals shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals.

2.14.1 Zone Annunciator

Provide a separate alarm and trouble lamp for each active and spare zone located on exterior of cabinet door or visible through the cabinet door. A minimum of two spare alarm zones that are fully operational shall be provided. Each lamp shall provide specific identification of the zone by means of a permanently attached rigid plastic or metal sign with either raised or engraved letters. Zone identification shall consist of a unique zone number as well as a word description of the zone.

2.14.2 System Zoning

The system shall be zoned as indicated.

2.14.3 Primary Power Supply

Primary power and trouble alarm power to the Control Panel shall be supplied from two 120 VAC circuits. Panel shall be equipped with two 20-amp circuit breakers for each control panel and with key lock. Panel shall be permanently marked "PREACTION SPRINKLER SYSTEM" or "DELUGE SPRINKLER SYSTEM".

2.14.4 Emergency Power Supply

Emergency power shall be provided for system operation in the event of failure of the primary power supply and shall consist of rechargeable storage battery system. Transfer from normal to emergency power or restoration from emergency to normal power shall be automatic and shall not cause transmission of a false alarm.

2.14.4.1 Storage Batteries

Storage Batteries shall be sealed, lead-calcium type requiring no additional water. Submit calculations to substantiate the total requirements for supervisory and alarm power. Include ampere-hour requirements for each system component and each control panel component or module, under both normal and alarm conditions. The battery recharging period shall be included with the calculations. The batteries shall have ample capacity, with primary power disconnected, to operate the system for a period of 90 hours. Following this period of operation via batteries, the batteries shall have ample capacity to operate all alarm indicating devices in the alarm mode for a minimum period of 15 minutes. Battery cabinet shall be a separate compartment at the bottom of the control panel. The battery cabinet shall have adequate space for spare duplicate storage batteries. Batteries shall be mounted on a noncorrosive and nonconductive base or pad.

2.14.4.2 Battery Charger

Battery charger shall be completely automatic, with high/low charging rate, capable of restoring the batteries from full discharge to full charge within 12 hours using the high charging rate. A separate ammeter shall be provided for indicating rate of charge. A separate voltmeter shall be provided to indicate the state of the battery charge. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly. The charger shall be located in control panel cabinet.

2.15 ALARM INITIATING DEVICES

2.15.1 Heat Detectors

Detectors located in areas subject to moisture, exterior atmospheric conditions or hazardous locations as defined in NFPA 70 shall be approved for such locations. Detectors shall be listed or approved for 15 m (50 foot) spacing between detectors. The detector shall be equipped with an alarm indicating light in its base that lights when the detector is in an alarm condition. Five spare detectors of each type and temperature rating shall be provided.

2.15.1.1 Rate Compensation Detector

Detector shall be of the vertical or horizontal spot type with a temperature classification rating of ordinary or intermediate as indicated on drawings and as defined by NFPA 72. Detectors listed or approved as "rate anticipation" type will be accepted. Detector shall automatically reset when temperature drops below detector temperature rating. Detector shall be hermetically sealed.

2.15.1.2 Fixed-Temperature and Rate-of-Rise Heat Detector

Detector shall consist of two independently operated thermal elements. The rate-of-rise portion of the detector shall consist of an air chamber, flexible metal diaphragm and a moisture-proof calibrated vent which will respond to a temperature rise exceeding 8 degrees C (15 degrees F) per minute. This portion of the detector shall be self-restoring after actuation. The fixed temperature portion of the detector shall consist of a fusible alloy that will melt and cause an alarm when the surrounding air rises above the temperature rating of the detector. The detector shall provide an external indication when the fixed temperature portion of the detector actuates. Detector shall have a temperature classification rating of ordinary or intermediate as defined by NFPA 72.

2.15.1.3 Fixed-Temperature Heat Detector

Detector shall have a fusible alloy that will melt and cause an alarm when the surrounding air rises above the temperature rating of the detector. The detector shall provide an external indication upon actuation of the detector. Detector shall provide a temperature classification rating as defined by NFPA 72.

2.15.2 Manual Actuation Station

Station shall be mounted at 1000 mm (42 inches) above the floor, unless otherwise shown. Station shall be arranged to activate the deluge system. Station shall be dual-action type requiring two separate operations in order to cause system discharge. Station shall be colored lime yellow . Station shall be provided with a positive visible indication of operation of the station. Station shall be weatherproof type and shall be provided with an engraved label indicating DELUGE SYSTEM.

2.15.3 Sprinkler Pressure Alarm Switch

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches. The switch shall have a service pressure rating of 1200 kPa 175 psi). There shall be two SPDT (Form C) contacts factory adjusted to operate at 30 to 60 kPa 4 to 8 psi). The switch shall be capable of being mounted in any position in the alarm line trim piping of the alarm check valve.

2.15.4 Waterflow Alarm

Electrically operated, exterior-mounted, waterflow alarm bell shall be provided and installed in accordance with NFPA 13. Waterflow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel (FACP) in accordance with Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. Or, if indicated on contract drawings, mechanically operated, exterior mounted, water motor alarm assembly shall be provided in accordance with NFPA 13. Water motor alarm assembly shall include a body housing, impeller or pelton wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 19 mm (3/4 inch) galvanized piping from the body housing shall be provided between the housing and the alarm check valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and outside surfaces.

2.15.5 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.16 NOTIFICATION APPLIANCES

Notification appliances shall be suitable for connection to supervised alarm indicating circuits. Appliance shall have a separate screw terminal for each conductor. The surface of the appliance shall be red in color.

2.16.1 Alarm Bell

Bell shall be 250 mm (10 inch) diameter, surface-mounted vibrating type with matching back box. Sound output shall be a minimum of 85 DBA at 3000 mm (10 feet). Bell shall operate on nominal 24 VDC. Bells shall have screw terminals for in-out wiring connection. Bells used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles.

2.16.2 Alarm Horn

Horn shall be surface mounted, with the matching mounting back box surface mounted or recessed, single or double projector, or grill and vibrating type suitable for use in an electrically supervised circuit. Horns shall operate on nominal 24 VDC and have screw terminals for in-out wiring connection. Sound output shall be a minimum of 85 DBA at 3000 mm (10 feet). Horns used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grills.

2.17 WIRING

Wiring for alternating current (AC) circuits shall be 12 AWG minimum. Wiring for low voltage direct current (DC) circuits shall be No. 16 or 14 AWG minimum. Power wiring (over 28 volts) and control wiring shall be isolated. Wiring shall conform to NFPA 70. System field wiring shall be solid copper and installed in electrical metallic tubing or in metallic conduit, except rigid plastic conduit may be used under slab-on-grade. Conductors shall be color coded. Conductors used for the same function shall be similarly color coded. Wiring color code shall remain uniform throughout the circuit. Pigtail or T-tap connections to alarm initiating, alarm indicating, supervisory, and actuation circuits are prohibited.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 31 00 00 EARTHWORK.

3.3 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of publications referenced herein.

3.4 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the sprinkler system periodically during the installation to assure that the sprinkler system installed in accordance with the contract requirements. The Fire Protection Specialist shall witness the preliminary and final tests, and shall sign the test results. The Fire Protection Specialist, after completion of the system inspections and a successful final test, shall certify in writing that the system has been installed in accordance with the contract requirements, including signed approval of the Preliminary, Detection and Control Systems, and Final Acceptance Test Reports. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.5 ABOVEGROUND PIPING INSTALLATION

3.5.1 Protection of Piping Against Earthquake Damage

Seismically protect the system piping against damage from earthquakes. This requirement is not subject to determination under NFPA 13. Install the seismic protection of the system piping, including sway bracing as required, in accordance with UFC 3-310-04, NFPA 13 and Annex A; submit load calculations for sizing of sway bracing for systems that are required to be protected against damage from earthquakes. Include the required features identified therein that are applicable to the specific piping system.

3.5.2 Piping in Exposed Areas

Exposed piping shall be installed so as not diminish exit access widths, corridors, or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.5.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings. Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.5.4 Pendent Sprinklers Locations

Sprinklers installed in the pendent position shall be of the listed dry pendent type, unless otherwise indicated. Dry pendent sprinklers shall be of the required length to permit the sprinkler to be threaded directly into a branch line tee. Hangers shall be provided on arm-overs to drop nipples supplying pendent sprinklers when the arm-over exceeds 300 mm (12 inches) for steel pipe or 150 mm (6 inches) for copper tubing. Dry pendent sprinkler assemblies shall be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.5.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm (30 inches) in length shall be individually supported.

3.5.6 Pendent Sprinklers Locations

Sprinklers installed in the pendent position shall be of the listed dry pendent type, unless otherwise indicated. Dry pendent sprinklers shall be of the required length to permit the sprinkler to be threaded directly into a branch line tee. Hangers shall be provided on arm-overs exceeding 300 mm (12 inches) in length. Dry pendent sprinkler assemblies shall be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.5.7 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings and fittings shall be from the same manufacturer. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.5.8 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 13 mm (1/2 inch).

3.5.9 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve in accordance with NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07 84 00 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.5.10 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.5.11 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm (1 inch) pipe connected to the remote branch line at the riser as a combination test and drain valve; a test valve located approximately 2 m (7 feet) above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test." The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.5.12 Drains

Provide main drain piping to discharge at a safe point outside the building or at the location indicated. Auxiliary drains shall be provided as indicated and as required by NFPA 13. When the capacity of trapped sections of pipe is less than 11 L (3 gallons), the auxiliary drain shall consist of a valve not smaller than 15 mm (1/2 inch) and a plug or nipple and cap. When the capacity of trapped sections of piping is more than 11 L (3 gallons), the auxiliary drain shall consist of two 25 mm (1 inch) valves and one 50 x 300 mm (2 x 12 inch) condensate nipple or equivalent, located in an accessible location. Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be a minimum of 25 mm (1 inch) in diameter. Tie-in drain lines shall be pitched a minimum of15 mm per 3 m (1/2 inch per 10 feet).

3.5.13 Installation of Fire Department Connection

Connection shall be mounted on the exterior wall approximately 900 mm (3 feet) above finished grade or adjacent to and on the sprinkler system side of the backflow preventer. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.5.14 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.6 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be 900 mm (3 feet). The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm (5 feet) outside the building walls shall meet the requirements of Section 33 11 00 WATER DISTRIBUTION.

3.7 ELECTRICAL WORK

Unless otherwise specified herein, power supply equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.7.1 Overcurrent and Surge Protection

All equipment connected to alternating current circuits shall be protected from surges in accordance with IEEE C62.41.1, IEEE C62.41.2 and NFPA 70. Cables and conductors that serve as communications links, except fiber optics, shall have surge protection circuits installed at each end. Fuses shall not be used for surge protection.

3.7.2 Grounding

Grounding shall be provided to building ground.

3.7.3 Wiring

System field wiring shall be installed in 20 mm (3/4 inch) minimum diameter electrical metallic tubing or metallic conduit. Wiring for the sprinkler system fire detection and control system shall be installed in tubing or conduits dedicated for that use only and not installed in conduit, outlet boxes or junction boxes which contain lighting and power wiring or equipment. Circuit conductors entering or leaving any mounting box, outlet box enclosure or cabinet shall be connected to screw terminals with each terminal marked and labeled in accordance with the wiring diagram. No more than one conductor shall be installed under any screw terminal. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors is not permitted. Wiring within any control equipment shall be readily accessible without removing any component parts. Conductors shall be color-coded and shall be identified within each enclosure where a connection or termination is made. Conductor identification shall be by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Circuits shall be wired to maintain electrical supervision so that removal of any single wire from any device shall cause a "trouble" condition on the control panel.

3.7.4 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 600 mm (24 inches) and not more than 2000 mm (78 inches) above the finished floor.

3.7.5 Detectors

Detectors shall be ceiling-mounted in accordance with NFPA 72 and shall be at least 300 mm (12 inches) from any part of any lighting fixture. Detectors shall be located at least 900 mm (3 feet) from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location.

3.7.6 Manual Actuation Stations

Manual actuation stations shall be mounted readily accessible and 1060 mm (42 inches) above the finished floor.

3.7.7 Notification Appliances

Notification appliances shall be mounted a minimum of 2400 mm (8 feet) above the finished floor unless limited by ceiling height.

3.8 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.9 PRELIMINARY TESTS

The system, including the underground water mains, the aboveground piping, detectors and control system and system components shall be tested to assure that equipment and components function as intended. Submit proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests, proposed date and time to begin the tests, submitted with the Procedures. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, complete and submit certificates as specified, and one hard copy & one digital copy (.pdf - text searchable) of the completed Preliminary Tests Reports, no later than 7 days after the completion of the Preliminary Tests. The Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

3.9.1 Underground Piping

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less that the calculated maximum water demand rate of the system.

3.9.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 2 L (2 quarts) per hour per 100 gaskets or joints, regardless of pipe diameter.

3.9.3 Aboveground Piping

3.9.3.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa (200 psi)) or 350 kPa (50 psi) in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.9.3.2 Air Pressure Test

As specified in NFPA 13, an air pressure leakage test at 350 kPa (50 psi) shall be conducted for 24 hours. There shall be no drop in gauge pressure in excess of 10 kPa (1.5 psi) for the 24 hours. This air pressure test is in addition to the required hydrostatic test.

3.9.3.3 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. Provide all equipment and instruments necessary to conduct a complete forward flow test, including 65 mm (2.5 inch) diameter hoses, playpipe nozzles, calibrated pressure gauges, and pitot tube gauge. Provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. A metal placard shall be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.9.4 Detection and Control System Tests

Upon completion of the installation, the detection and control system shall be subjected to functional and operational performance tests including tests of each installed initiating device, system actuation device and notification appliance. The control system tests specified in paragraph FINAL ACCEPTANCE TESTS shall be conducted to ensure that the system is completely functional and that wiring has been properly connected. If deficiencies are found, corrections shall be made and the system shall be retested to assure that the systems have no deficiencies.

3.9.5 Automatic Water Control Valve Test

Each water control valve shall be independently trip-tested in accordance with the manufacturer's published instructions. Each valve shall be electrically trip-tested by actuating a respective heat detector and a manual actuation station connected to the control panel and a manual actuation device that is part of the valve trim. A full-flow main drain test shall be made. For preaction systems with supervisory air, the air pressure shall be reduced to verify proper operation of the air supply system and associated supervisory alarm devices.

3.10 FINAL ACCEPTANCE TESTS

Final Acceptance Test shall begin only when the Preliminary Test Report has been approved. The Fire Protection Specialist shall conduct the Final Acceptance Test; submit the proposed procedures and notificationfor Final Acceptance Tests, no later than 14 days prior to the proposed start of the tests, the proposed date and time to begin Final Acceptance Tests, submitted with the Final Acceptance Test Procedures. and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. Each system shall be completely drained after each trip test. The system air supply system shall be tested to verify that system pressure is restored in the specified time. Submit one hard copy and one digital copy (.pdf - text searchable) of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Report shall be signed by the Fire Protection Specialist In addition, the Fire Protection Specialist shall have available copies of as-built drawings and certificates of tests previously conducted. Submit as-built drawings, no later than 14 days after completion of the Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received. After the system has been tested and drained, the system shall be drained periodically for at least 2 weeks until it can be assured that water from the system has been removed.

3.10.1 Control System Test

Testing shall be in accordance with NFPA 72. The test shall include the following:

a. Visual inspection of wiring connections.

b. Opening the circuit at each alarm initiating device, solenoid valve, and notification appliance to test the wiring and supervisory features.

c. Test of each function of the control panel.

d. Test of each circuit in the normal, open and ground fault modes.

e. Test of each initiating device in both normal and trouble conditions.

f. Test of each control circuit and device.

g. Test of each alarm notification appliance.

h. Test of the battery charger and batteries.

i. Operational tests under emergency power supply, including activation of connected alarm notification appliances for the specified time period.

3.10.2 Trip-tests of Automatic Water Control Valves

Each water control valve shall be independently trip-tested in accordance with the manufacturer's published instructions. Each valve shall be electrically trip-tested by actuating a respective heat detector, a manual actuation station connected to the system control panel and the manual release which is part of the valve trim. Each valve shall be returned to normal condition after each test. A full-flow main drain test shall be made. For preaction systems with supervisory air, the air pressure shall be reduced to verify proper operation of the air supply system and associated supervisory alarm devices. Prior to trip testing sprinkler deluge system, precautionary steps shall be taken to prevent water damage to the building and equipment from sprinkler discharge.

3.10.3 Tests of Supervisory Air System

Preaction system supervisory air pressure shall be reduced from the normal system pressure to the point at which a low-pressure alarm is sounded. Air pressure shall be restored to verify trouble signal restoration. Automatic start/stop features of air compressor shall be tested.

3.11 ONSITE TRAINING

The Fire Protection Specialist shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit proposed Onsite Training schedule, at least 14 days prior to the start of related training. Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete and after the Final Acceptance Test. The Onsite Training shall cover all of the items contained in the approved Operating and Maintenance Instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

-- End of Section --

SECTION 21 13 24.00 10

AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1013	(2011) Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and

	Other Special Purpose Applications
ASTM A312/A312M	(2014b) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A351/A351M	(2014) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A403/A403M	(2014) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A795/A795M	(2013) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM F436	(2011) Hardened Steel Washers
ASTM F436M	(2011) Hardened Steel Washers (Metric)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 11	(2010; TIA 10-1) Standard for Low-, Medium- and High- Expansion Foam
NFPA 13	(2013; TIA 10-1; TIA 11-2; ERTA 2014; TIA 14-3) Standard for the Installation of Sprinkler Systems
NFPA 16	(2011) Standard for Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
NFPA 1963	(2014) Standard for Fire Hose Connections
NFPA 20	(2013) Standard for the Installation of Stationary Pumps for Fire Protection
NFPA 24	(2013) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2010) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Water Based Systems Layout

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-F-24385	(1992; Rev F; Am 1 1994) Fire Extinguishing Agent, Aqueous Film Forming Foam (AFFF) Liquid Concentrate, for Fresh and Seawater

UNDERWRITERS LABORATORIES (UL)

UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service

1.2 SYSTEM DESCRIPTION

a. Provide an AFFF System consisting of an automatic wet-pipe, preaction, or deluge foam-water fire protection system used for the areas indicated on the drawings. Submit a copy of the proposed diagrams and instructions for the overall AFFF system, prior to posting. Except as modified herein, the system shall meet the requirements of NFPA 11, NFPA 13, NFPA 16, NFPA 24 and NFPA 72.

b. The wet-pipe sprinkler system shall operate so that actuation of a single sprinkler will cause water to flow through the alarm check valve, foam concentrate to enter the affected proportioners, and foam-water solution to be discharged from actuated sprinklers and the nozzle system.

c. The single-interlocked preaction sprinkler system (without supervisory air) shall operate so that actuation of a single heat detector or manual release will cause the automatic water control (deluge) valve to open, foam concentrate to enter the affected proportioners, and foam-water solution to be discharged from actuated sprinklers and the nozzle system.

d. The deluge sprinkler system shall operate so that actuation of a single heat detector or manual release will cause the automatic water control (deluge) valve to open, foam concentrate to enter the affected proportioners, and foam-water solution to be discharged from all sprinklers on the system and the nozzle system.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

One hard copy & one digital copy of detail drawings conforming to the requirements prescribed in NFPA 13. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES and shall include plan and elevation views which establish that the equipment will fit the allotted spaces with clearance for installation and maintenance.

As-built Drawings

As built drawings within 14 calendar days after successful completion of required testing. As-built shop drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

A separate set of approved submittal drawings of the overall system, marked up to indicate as-built conditions, shall be maintained onsite in a current condition at all times and shall be made available for review immediately upon request during normal working hours. Variations from the approved drawings, for whatever reason, including those occasioned by modifications, change orders, optional materials, and/or required for coordination between trades shall be indicated in sufficient detail to accurately reflect the as-built conditions.

SD-03 Product Data

Materials and Equipment; G

Manufacturer's catalog data for each separate piece of equipment proposed for use in the system. Data shall indicate the name of the manufacturer of each item of equipment, with data highlighted to indicate model, size, options, etc. proposed for installation. In addition, provide a complete equipment list with equipment description, model number, and quantity and certificates from manufacturers to substantiate that components, equipment and material proposed for installation and use meet requirements as specified. Certificates shall be on a form for this purpose or on official letterhead of the manufacturer with specified information stated as required. Certificate shall be signed by an officer of the corporation.

Spare Parts

Spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

AFFF System; G

A copy of the proposed diagrams and instructions for the overall AFFF system, prior to posting.

Installer's Qualifications; G

A statement attesting that the proposed installer is regularly engaged in the installation of the type and complexity of system included in this project; data identifying the locations of at least three systems recently installed by the proposed installer which are comparable to the system specified; and certification that each system has performed satisfactorily, in the manner intended, for a period of not less than 6 months.

Post-discharge Test Requirements; G

Following the successful completion of the tests, confirmation of the following:

a. Removal of the foam solution from the site as indicated on the approved AFFF waste containment and disposal plan.

b. Replenishment of AFFF concentrate consumed during the tests.

c. Confirmation that entire fire protection system has been returned to automatic operation and fully operational status, including filling of AFFF concentrate tanks with concentrate and filling of solution piping with premix as required, and the facility has been restored to operational capability.

d. Containment and disposal of discharged solution in a manner acceptable to local authorities and as identified on the approved test plan.

SD-06 Test Reports

Test Reports; G

Test reports and videotapes as specified.

SD-07 Certificates

Materials and Equipment; G

Certificates for the following:

a. AFFF concentrate proposed for use has been tested and is in compliance with MIL-F-24385

b. AFFF concentrate control valve is designed and, constructed as specified and will function as intended.

c. AFFF proportioning system complies with contract specifications and manufacturer's recommendations.

d. Control panel releasing module is electrically compatible with the electrically-actuated automatic water control valve.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

One hard copy and one digital copy (.pdf - text searchable) of manuals in loose-leaf binder format and grouped by technical sections consisting of manufacturer's brochures, schematics, printed instructions, general operating procedures, and safety precautions. Manuals shall include a narrative description of the sequence or sequences of operation of the overall fire protection system and a separate description for each major subsystem. Information to be provided shall include specific start/stop settings for pumps, open/close settings for all adjustable valves (including pressure sustaining and relief valves) shall be included. The manuals shall list routine maintenance procedures, possible breakdowns, and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout, simplified wiring and control diagrams for the system as installed, procedures and instructions pertaining to frequency of preventive maintenance, inspection, adjustment, lubrication and cleaning necessary to minimize corrective maintenance and repair.

1.4 QUALITY ASSURANCE

The advisory provisions of NFPA standards and recommended practices specified shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears. In the event of a conflict between referenced NFPA standards and this specification, this specification shall govern. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

1.4.1 Submittal Preparer's Qualifications

The fire protection system submittals, including as-built drawings, shall be prepared by an individual who is either a registered professional engineer with ten years experience designing AFFF systems or who is certified as a Level IV Technician by National Institute for Certification in Engineering Technologies (NICET) in the Water Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. Submit as built drawings within 14 calendar days after successful completion of required testing. As-built shop drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. A separate set of approved submittal drawings of the overall system, marked up to indicate as-built conditions, shall be maintained onsite in a current condition at all times and shall be made available for review immediately upon request during normal working hours. Variations from the approved drawings, for whatever reason, including those occasioned by modifications, change orders, optional materials, and/or required for coordination between trades shall be indicated in sufficient detail to accurately reflect the as-built conditions.

1.4.2 Installer's Qualifications

The installer shall be experienced and regularly engaged in the installation of the type and complexity of fire protection system included in this project. Provide a statement attesting that the proposed installer is regularly engaged in the installation of the type and complexity of system included in this project. Submit, in addition, data identifying the locations of at least three systems recently installed by the proposed installer which are comparable to the system specified. Certify that each system has performed satisfactorily, in the manner intended, for a period of not less than 6 months.

1.4.3 Detail Drawings

Submit one hard copy & one digital copy of detail drawings conforming to the requirements prescribed in NFPA 13. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES and shall include plan and elevation views which establish that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

a. A descriptive index with drawings listed in sequence by number. A legend sheet identifying device symbols, nomenclature, and conventions used in the package.

b. Floor plans drawn to a scale not less than 1:100 (1/8 inch equals 1 foot) clearly showing locations of devices, equipment, risers, electrical power connections, flame detector viewing areas, areas covered by each nozzle, and other details required to clearly describe the proposed arrangement.

c. Piping plan for each individual sprinkler system and each nozzle system. Sprinklers, nozzles and associated piping shall be shown. Abbreviated presentation forms will not be accepted. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be identified. A separate plan shall be provided for each overhead sprinkler system and each nozzle system.

d. Piping plan and isometric drawing of the AFFF concentrate system and details of all associated pumps, valves, fittings, and other components. Drawing shall indicate all operational features including, but not limited to, settings for pump start/stop, relief valve open/close, pressure sustaining valve open/close.

e. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; and from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling.

f. Location of control panels, detectors, manual stations, supervisory switches, solenoids, notification appliances, and other electrical devices. In addition, conduit routing and sizes, and the number of conductors contained in each shall be indicated.

g. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing and elevation of each typical sprinkler above finished floor.

h. Equipment room layout drawings drawn to a scale of not less than 1:20 (1/2 inch equals 1 foot) to show details of each system component, clearances between each other and from other equipment and construction in the room.

i. Details of each type of pipe hanger, sway bracing for earthquake protection, restraint of underground water main at point-of-entry into the building, proportioners, nozzles and mounting details, AFFF system control valve header and related components.

j. Connection drawings and control diagrams indicating overall electrical and mechanical operation of the AFFF system. This shall include identification and operation of each major component of the system. Diagrams shall be supplemented with a narrative description of the system. Point-to-point wiring diagrams shall indicate foam system control panel wiring and make and model of devices and equipment connected thereto.

k. Detail drawings depicting actual wiring of AFFF pump controller and all interconnecting wiring to foam concentrate pumps and other components connected to the controller. Such drawing shall be specifically prepared for the project installation. Manufacturer's standard wiring diagrams will not be accepted.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit manufacturer's catalog data for each separate piece of equipment proposed for use in the system. Data shall indicate the name of the manufacturer of each item of equipment, with data highlighted to indicate model, size, options, etc. proposed for installation. In addition, provide a complete equipment list with equipment description, model number, and quantity and certificates from manufacturers to substantiate that components, equipment and material proposed for installation and use meet requirements as specified. Certificates shall be on a form for this purpose or on official letterhead of the manufacturer with specified information stated as required. Certificate shall be signed by an officer of the corporation. Submit certificates for the following:

a. AFFF concentrate. Certification that AFFF concentrate proposed for use has been tested and is in compliance with MIL-F-24385.

b. AFFF concentrate control valve. Certification that the valve is designed and, constructed as specified and will function as intended.

c. AFFF proportioning system. Certification that the foam proportioning system complies with contract specifications and manufacturer's recommendations.

d. Control panel. Certification that the control panel releasing module is electrically compatible with the electrically-actuated automatic water control valve.

2.2 NAMEPLATES

Major components of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate permanently affixed to the item of equipment.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

All equipment and material shall have been tested by Underwriters Laboratories, and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement.

2.4 PRESSURE RATINGS

Valves, fittings, couplings, proportioners, alarm switches, strainers, and similar devices shall be rated for the maximum working pressures that can be experienced in the system, but in no case less than 1200 kPa (175 psi).

2.5 UNDERGROUND PIPING SYSTEMS

Pipe shall be ductile iron pipe conforming to AWWA C151/A21.51, working pressure not less than 1034 kPa (150 psi), with cement-mortar lining conforming to AWWA C104/A21.4 for piping under the building and to a point 1.5 m (5 feet) outside the building walls. Fittings shall be ductile iron conforming to AWWA C110/A21.10. Piping more than 1.5 m (5 feet) outside the building walls shall be in accordance with SECTION 33 11 00 WATER DISTRIBUTION.

2.6 ABOVEGROUND PIPING SYSTEMS FOR WATER OR AFFF SOLUTION

2.6.1 Pipe

Pipe shall be standard weight conforming to ASTM A795/A795M or ASTM A53/A53M or KS D 3562. Pipe 150 mm (6 inch) diameter and smaller shall be Schedule 40. Pipe shall be marked as to the brand or name of the manufacturer, kind of pipe and the ASTM designation in accordance with the "Product Marking" provisions of the ASTM standard.

2.6.2 Grooved Fittings and Couplings

Grooved fittings, couplings and bolts shall be provided by the same manufacturer. Fittings and couplings shall be malleable iron complying with ASTM A47/A47M or ductile iron complying with ASTM A536. Couplings shall be of the rigid type except that flexible type will be provided where flexible joints are specifically required by NFPA 13. Coupling gaskets shall be Grade E (EPDM) approved for dry pipe fire protection service. Gasket shall be the flush type that fills the entire cavity between the coupling and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.6.3 Non-Grooved Fittings

Non-grooved fittings shall be threaded or flanged. Threaded fittings shall be cast iron conforming to ASME B16.4 or malleable iron conforming to ASME B16.3 or KS B 1531. Flanged fittings shall be cast iron conforming to ASME B16.1. Fittings into which sprinklers, drop nipples or riser nipples (sprigs) are screwed shall be threaded type. Plain-end fittings with mechanical couplings, fittings which require drilling a hole in the pipe, and fittings which use steel gripping devices to bite into the pipe, shall not be used.

2.6.4 Flanges and Gaskets

Flanges shall conform to NFPA 13 and ASME B16.1. Flanges shall be the type that are welded or threaded to the pipe. Flanges which are bolted to grooved pipe will not be permitted. Gaskets shall be full face type EPDM or other approved material.

2.6.4.1 Bolts

Bolts shall be ASTM A449, Type 1 or 2. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

2.6.4.2 Nuts

Nuts shall be ASTM A193/A193M, Grade 5 orASTM A563M (ASTM A563), Grade C3 or DH3.

2.6.4.3 Washers

Washers shall meet the requirements of ASTM F436M (ASTM F436). Flat circular washers shall be provided under all bolt heads and nuts.

2.6.5 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM APP GUIDE and be of the type suitable for the application, construction and size pipe involved.

2.6.6 Control Valve

Unless otherwise indicated, valves shall be indicating type in accordance with NFPA 13. Valves 65 mm (2-1/2 inch) and larger shall be flanged outside screw and yoke (OS&Y) type.

2.6.7 Check Valve

Check valves 100 mm (4 inches) and larger shall be flanged, swing type, cast or ductile iron body and cover, cast or ductile iron clapper with replaceable EPDM rubber facing. Valves shall be suitable for either vertical or horizontal mounting and equipped with a removable handhole cover. The direction of flow shall be indicated by an arrow cast in the valve body. The valve body shall include plugged pipe thread connections for a 50 mm (2 inch) drain.

2.7 ABOVEGROUND PIPING SYSTEMS FOR AFFF CONCENTRATE

2.7.1 Pipe

Pipe shall be standard weight stainless steel conforming to ASTM A312/A312M, Grade TP 304L.

2.7.2 Fittings

Seamless socket weld type or flanged type fittings shall conform to ASTM A403/A403M, Grade WP 304L, and shall be compatible with the pipe. Grooved type fittings and couplings shall be of Type 316 Stainless Steel conforming to ASTM A351/A351M.

2.7.3 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM APP GUIDE and be of the type suitable for the application, construction and size pipe involved.

2.7.4 Control Valves

Valve shall be indicating type with full port ball and operating handle that indicates the on/off position of the valve. Unit shall be socket weld or flanged type. Valve body and ball shall be of 316 stainless steel complying with ASTM A351/A351M. The valve handle shall be provided with a suitable and substantial means for securing the valve open with a key-operated locking device.

2.8 ALARM CHECK VALVE ASSEMBLY

Alarm check valve assembly shall be of the variable pressure type rated for working pressures of between 1207 kPa (175 psi) and 1724 kPa. Assembly shall be provided with standard trimmings including pressure gauges, retarding chamber, alarm line vent, testing bypass, and necessary pipe, fittings, and accessories required for a complete installation. Valve trim piping shall be brass. Such piping shall include provision for installing an alarm pressure switch in a non-interruptible arrangement whereby shutting off of other alarm devices will not shutoff the switch in the non-interruptible location.

2.9 AUTOMATIC WATER CONTROL VALVE ASSEMBLY (DELUGE VALVE)

Water control valve shall be an electrically-actuated type rated for a maximum working pressure of between 1207 kPa (175 psi) and 1724 kPa (250 psi). The control valve shall be resettable without opening the valve and without the use of special tools. Electrical solenoid valve used to actuate the water control valve shall be an integral component of the valve or shall be approved for use by the water control valve manufacturer and the control panel manufacturer. Solenoid valve shall be of the normally closed, de-energized type which opens when energized upon receipt of an electrical signal from the control panel to which it is connected. Solenoid valves used with diaphragm-type valves shall be rated for a maximum pressure equal to that of the associated valve. Water control valve shall be equipped with a means to prevent the valve from returning to the closed position until being manually reset. Assembly shall be complete with the valve manufacturer's standard trim piping, drain and test valves, pressure gauges, and other required appurtenances. Each assembly shall include an emergency release device for manually tripping the water control valve in the event of a power or other system failure. Device shall be a standard accessory component of the valve manufacturer and shall be labeled as to its function and method of operation. Valves located in hazardous locations shall be approved for the hazard classification of the area where located.

2.10 MECHANICAL ALARM DEVICE

Device shall be water-powered and shall include a body housing, impeller wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 20 mm (3/4 inch) piping shall be provided between the housing and the alarm line trim. Drain piping from the body housing shall be minimum 25 mm (1 inch) steel and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and on the outside surfaces.

2.11 FIRE DEPARTMENT CONNECTION

Connection shall be projecting or flush type with cast brass body, a polished brass or chromium plated finish, and matching wall escutcheon lettered "Auto Spkr". The connection shall have two inlets with individual self-closing clappers, caps with drip drains, and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) in accordance with NFPA 1963.

2.12 BASKET STRAINER

Unit shall have cast iron flanged body and cover flanges. The strainer basket shall be formed of perforated brass or stainless steel sheet with 6 mm (1/4 inch) perforations. Strainer size and maximum friction loss shall be as indicated in drawings. Assembly shall allow access to the strainer basket by removing the flange on the top of the strainer.

2.13 REDUCED PRESSURE BACKFLOW PREVENTION ASSEMBLY

The unit shall be capable of preventing back-siphonage and back pressure backflow from the fire protection system into the potable water system. The assembly shall include a pressure differential relief valve located in a zone between two positive seating check valves. The assembly shall include resilient seated outside stem and yoke (OS&Y) gate valves upstream and downstream of the valve and test cocks. Main valve body shall be ductile iron with fused bonded epoxy coating. The assembly shall comply with ASSE 1013 and be listed in UL Fire Prot Dir or FM APP GUIDE.

2.14 DISCHARGE DEVICES

2.14.1 Sprinkler

Sprinkler shall be 13 mm (1/2 inch) orifice spray type. For deluge systems, sprinkler shall be open type without heat responsive and actuating elements. For wet-pipe or preaction systems, sprinkler shall be upright type with standard response or quick response glass bulb heat responsive and actuating element having a temperature rating of 79 degrees C (175 degrees F). Spare sprinklers in accordance with NFPA 13 shall be housed in metal or plastic containers.

2.14.2 Fixed Nozzle

Nozzle shall be of fixed constant flow type, cast brass construction 25 or 40 mm (1 or 1-1/2 inch) male NPT, suitable for use with AFFF solution. Nozzle shall be factory set for required discharge characteristic. Discharge characteristic or k-factor(s) shall be as indicated on the drawings. Nozzle discharge pattern shall be field adjustable and lockable. Nozzle flow and effective reach of discharge at various nozzle patterns shall have been determined by the manufacturer's actual discharge tests with nozzles in horizontal pattern at nozzle pressures of 345 kPa (50 psi), 517 kPa (75 psi) and 689 kPa (100 psi). Nozzle settings shall be factory set. Field disassembly, adjustment or assembly which could alter discharge characteristic will not be permitted.

2.14.3 Oscillating Monitor Nozzle Assembly

Assembly shall include water-powered oscillator, monitor, nozzle, and related ancillary components which shall be the product of one manufacturer. Water-powered oscillating mechanism shall be equipped with a strainer. Assembly shall include a test connection for operating the oscillator from an auxiliary water source without requiring discharge through the nozzle. Angle of elevation shall be adjustable from 20 degrees below to 60 degrees above horizontal. Oscillation arc shall be adjustable from 10 degrees to 165 degrees and speed shall be adjustable from 0 degrees to 30 degrees per second. Components in contact with the AFFF solution shall be compatible with the foam concentrate and metallic components shall be brass, bronze or stainless steel. Nozzle shall be a standard model of the manufacturer and shall have a fixed discharge characteristic. Nozzle discharge characteristic shall have been determined by discharge tests. Monitor nozzle assembly shall be approved by Factory Mutual and listed in FM APP GUIDE.

2.15 AFFF LIQUID CONCENTRATE

AFFF concentrate shall be 3 percent conforming to MIL-F-24385. Concentrate shall be the product of one manufacturer. Mixing of non-identical brands of concentrate will not be permitted.

2.16 DIAPHRAGM TANK BALANCED PRESSURE PROPORTIONING SYSTEM

Tank shall be a steel pressure vessel constructed in accordance with ASME BPVC SEC VIII D1. ASME label shall be permanently affixed to the tank. Tank shall be horizontally mounted on steel saddles and shall contain a full internal diaphragm (bladder) having a minimum capacity as indicated on drawings. Diaphragm shall be nylon-reinforced Buna-N rubber or other approved material conforming to the inside shape of the tank. AFFF concentrate shall be stored inside the diaphragm and the concentrate shall not be in contact with the steel tank. The tank shall have perforated PVC tubes installed inside the diaphragm to assure full displacement of the stored concentrate. Tank shall be equipped with the manufacturer's standard fittings and trim, including AFFF fill and drain connections, water fill and drain connections, and concentrate sight gauge.

2.17 PUMPED BALANCED PRESSURE PROPORTIONING SYSTEM

2.17.1 AFFF Concentrate Storage Tank

Tank shall be designed for storage of AFFF concentrate at atmospheric pressure and shall be vertical cylindrical, high density cross-linked polyethylene construction. Individual tank capacity shall be as indicated on drawings. Tank shall be translucent and equipped with level gauge strip for approximating quantity of tank contents. Tank shall be equipped with the following: inspection hatch; valved drain/fill connection; foam concentrate pump suction and return connections (with flex connectors); pressure/vacuum vent; low liquid level float switch; seismic tie downs and other accessories required for proper operation shall be in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT . Openings and tank connections shall be installed at the factory, no holes shall be made in the tank shell in the field. Tank shall include necessary supports for free standing installation.

2.17.2 AFFF Concentrate Pump

Pump shall be a positive displacement rotary gear or vane type operating at a speed not greater than 1800 rpm. Pump capacity shall be as indicated on the drawing. Minimum pump discharge pressure shall be as indicated on drawings.Metallic pump components in contact with AFFF concentrate shall be of bronze or stainless steel construction. Each pump shall be furnished with suction strainer, relief valve, and suction and discharge gauges. Pump shall be mounted on a carbon steel base and shall have guards over couplings. Pump shall be direct-connected to electric motor with drip-proof enclosure. Minimum motor size shall as indicated on drawings.

2.17.3 AFFF Pump Controller

Controller shall be the automatic type and UL listed or FM approved for fire pump service and shall be arranged for automatic start and stop, and manual push-button stop of the AFFF pump it controls. Controller shall be completely terminally wired, ready for field connections, and mounted in a NEMA Type 2 drip-proof or NEMA Type 4 watertight and dust tight enclosure arranged so that controller current carrying parts will not be less than 300 mm (12 inches) above the floor. The controller shall be equipped with an externally operable isolating switch which manually operates the motor circuit. Means shall be provided in the controller for measuring current for all motor circuit conductors. Controller shall cause pump to run for a minimum of ten (10) minutes prior to automatic shutdown. Automatic stopping shall be accomplished only after all starting causes have returned to normal and after the minimum pump run time has elapsed. Controller shall also cause pump to stop upon signal from low liquid level switch installed in the AFFF concentrate tank. Controller shall monitor and provide individually displayed audible and visual alarms on the front panel for loss of a phase or line power, phase reversal, low AFFF concentrate level, and pump room temperature. Each alarm lamp shall be labeled with rigid etched plastic labels. The controller shall be equipped with the following:

a. Voltage surge arresters installed in accordance with NFPA 20.

b. Bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments, automatic starting relay actuated from normally closed contacts, visual alarm lamps and supervisory power light.

c. Thermostat switch with adjustable setting to monitor the pump room temperature and to provide an alarm when temperatures falls below 5 degrees C (40 degrees F).

d. Terminals for remote monitoring of pump running, pump power supply trouble (loss of power or phase and phase reversal), and pump room trouble (pump room temperature and low reservoir level, and for remote start.

e. A 7-day electric pressure recorder with 24-hour spring wound back-up. The pressure recorder shall provide a readout of the system pressure from 0 to 2067 kPa (0 to 300 psi), time, and date.

2.17.4 Power Supply

The source and arrangement of power supply to the pumps shall be as shown on the drawings and in accordance with NFPA 20.

2.17.5 AFFF Pressure Maintenance Pump

Pump shall be provided as indicated to maintain pressure on the AFFF concentrate distribution piping. Pump construction and components shall be similar to those provided for the primary AFFF concentrate pump. Pressure maintenance pump shall have a capacity and pressure rating of as indicated on the drawing.

2.17.6 Pressure Balancing Valve

Pressure balancing valve shall be diaphragm type for balancing AFFF concentrate with water pressure. Valve body and other metallic components normally in contact with the AFFF concentrate shall be of bronze or stainless steel. Unit shall be rated for working pressure of 1379 kPa (200 psi) and shall include a manual bypass and duplex gauge for monitoring water pressure and AFFF concentrate pressure.

2.17.7 Pressure Sustaining Valve

Pressure regulating valve shall be a pressure sustaining back pressure type, hydraulically operated, pilot controlled, modulating type arranged to maintain constant upstream pressure in the AFFF concentrate piping system as the flow rate varies. Valve body and other metallic components normally in contact with the AFFF concentrate shall be of bronze or stainless steel construction. Valve body shall be designed with flat-faced flanges to match flanges of the same nominal size. Valve shall pass the unused portion of the AFFF liquid back to the storage tank under low system flow conditions. Valve shall be sized to pass the full AFFF liquid pump output of a single foam concentrate pump.

2.18 BALANCED PRESSURE PROPORTIONER (RATIO CONTROLLER)

The proportioner shall be a standard or an in-line balanced pressure type unit capable of proportioning AFFF liquid at 3 percent, (3 parts concentrate to 97 parts water by volume solution) at flow rates within the flow range of the proportioner. Major components of the proportioner, including the body, inlet nozzle and metering orifice shall be of brass, bronze or stainless steel. The body shall be clearly marked with a flow-direction arrow, and the type and percent of AFFF concentrate that it was designed to proportion. proportioner size and maximum friction loss shall be as indicated in the contract drawings.The in-line balanced pressure proportioner shall be an assembly that includes a proportioner as described, integral pressure balancing valve with duplex pressure gauge, inlet pressure gauge and manual ball valve. The proportioner assembly shall be factory assembled and tested as an assembly by one manufacturer. Field disassembly or assembly of any component part will not be accepted. Components shall be of the make/model required by the specific UL listing or FM approval.

2.19 AFFF CONCENTRATE CONTROL VALVE ASSEMBLY

Assembly shall be specifically designed and constructed to control AFFF concentrate to proportioners and shall be arranged to open upon application of water or AFFF solution pressure from the alarm check or automatic water control valve to which it is connected. Valve shall be a listed or approved automatic control valve specifically intended for this application or a full port ball valve. All components shall be constructed of brass, bronze or stainless steel, except that the internal portions of listed or approved fire protection valves subjected to AFFF concentrate may be provided with a coating warranted by the manufacturer to protect the valve from the deleterious effects of the concentrate. All components shall be rated for working pressure of 1200 kPa (175 psi) or maximum working pressure to which they could be subjected, whichever is greater. Valve shall be certified by the manufacturer to be operable with water inlet pressure as low as 207 kPa (30 psi). Valve components shall be brass, bronze or stainless steel.

2.20 FOAM SYSTEM CONTROLS

Panel shall be UL listed or FM approved for "Releasing Device Service" or shall have modules approved for this purpose. Panel shall contain components and equipment required to provide the specified operational and supervisory functions of the system. Components shall be housed in a surface or flush mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly factory assembled and wired unit. Panel shall include integral "power on," "alarm," and "trouble" lamps with annunciation of each alarm, supervisory and trouble signal. The panel shall have prominent rigid plastic or metal identification plates for zones, indicating lights, controls, meters, and switches. Lamps and fuses mounted on circuit boards shall be identified by permanent markings on the circuit board. Nameplates for fuses shall also include ampere rating. Control panel switches shall be within the locked cabinet. A suitable means shall be provided for testing the control panel visual indicating devices (meter and lamps). Meters and lamps shall be plainly visible when the cabinet door is closed. Signals shall be provided to indicate and annunciate, by zone, any alarm, supervisory or trouble condition on the system. Upon restoration of power, start-up shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals. Where the panel controls continuous linear thermal detection cable, the panel shall be fully compatible with the cable, as certified by the cable manufacturer. In such applications, the panel shall be capable of controlling multiple independent adjustable fixed temperature set points to achieve the effect of a rate-of-rise detector. The panel shall be capable of identifying the location of a hot spot along the length of the detector cable and providing a constant temperature readout.

2.20.1 Zone Annunciator

Visual annunciators shall be provided for each active zone and spare zone. A separate alarm and trouble lamp shall be provided for each zone and shall be located on the exterior of the cabinet door or be visible through the door. A minimum of two spare alarm zones that are fully operational shall be provided. Each lamp shall provide specific identification of the zone by means of a permanently attached rigid plastic or metal sign with either raised, engraved or silk-screened letters. Zone identification shall consist of a unique zone number as well as a word description of the zone. Zones shall be arranged as shown on the drawings.

2.20.2 System Zoning

The system shall be zoned as indicated in drawings.

2.20.3 Primary Power Supply

Primary power and trouble alarm power to Control Panel shall be supplied from two 120 VAC circuits. Power to the control panel shall be as indicated. Panel shall be equipped with two 20-amp circuit breakers for each control panel and with key lock. Panel shall be permanently marked "FOAM FIRE PROTECTION SYSTEM".

2.20.4 Emergency Power Supply

Emergency power shall be provided for system operation in the event of failure of the primary power supply and shall consist of rechargeable storage battery system. Transfer from normal to emergency power or restoration from emergency to normal power shall be automatic and shall not cause transmission of a false alarm.

2.20.4.1 Storage Batteries

Storage Batteries shall be sealed, lead-calcium type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the system for a period of 90 hours. Following this period of operation via batteries, the batteries shall have ample capacity to operate alarm indicating devices in the alarm mode for a minimum period of 15 minutes. Battery cabinet shall be a separate compartment within the control panel. The battery compartment or cabinet shall have twice the volume of the batteries. Batteries shall set on a non-corrosive and non-conductive base or pad. Batteries in the control panel shall be located at the bottom of the panel.

2.20.4.2 Battery Charger

Battery charger shall be completely automatic, with high/low charging rate, capable of restoring the batteries from full discharge to full charge within 24 hours. A separate ammeter shall be provided for indicating rate of charge. A separate voltmeter shall be provided to indicate the state of the battery charge. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly if a high rate switch is provided. Charger shall be located in control panel cabinet.

2.21 ALARM INITIATING DEVICES

2.21.1 Waterflow Pressure Alarm Switch

Unit shall include a 13 mm (1/2 inch) NPT male pipe thread, two 13 mm (1/2 inch) conduit knockouts, and two sets of SPDT (Form C) contacts. The switches shall be factory adjusted to transfer the contacts at 27.6 to 55.1 kPa (4 to 8 psi) on rising pressure. Unit shall include a water-tight NEMA 4 die-cast aluminum housing with a tamper resistant cover which requires a special key for removal. The cover shall be provided with a tamper switch which shall operate upon removal of the cover. Units used on wet-pipe systems shall have an adjustable, instantly recycling pneumatic retard to prevent false alarms due to water pressure variation. Retard adjustment shall be factory set at approximately 20-40 seconds and adjustable between 0-90 seconds.

2.21.2 Vane-type Waterflow Switch

Assembly shall consist of a cast aluminum pipe saddle housing an electro-mechanical device to which is attached a flexible, low-density polyethylene paddle. The paddle shall conform to the inside diameter of the fire protection pipe and sense water or solution movements. The waterflow indicator shall be capable of detecting a sustained flow exceeding 0.63 L/second (10 gpm). Assembly shall contain a pneumatic retard device adjustable from 0 to 90 seconds to reduce the possibility of false alarms caused by transient flow surges. The unit shall include two sets of SPDT (Form C) contacts. The unit shall be equipped with a silicone rubber gasket to assure positive water seal and a dust-proof cover and gasket to seal the mechanism from dirt and moisture.

2.21.3 Heat Detector-Spot Type

Detector shall be weatherproof, of the rate-compensation type with a nominal temperature rating of 76 degrees C (170 degrees F). Detector shall be listed or approved for spacing between detectors as shown. Detectors listed or approved as "rate anticipation" type will be accepted. Detectors utilizing the fixed-temperature, rate-of-rise, or combination fixed-temperature/rate-of-rise principles will not be accepted. Six spare detectors of each type and temperature rating shall be provided.

2.21.4 Continuous Linear Thermal Detector

Detector shall be line-type electrical conductivity fixed temperature coaxial wire capable of sensing temperature changes along its entire length and operate over a wide range of temperatures. The detector cable shall be constructed of a center conductor having a maximum diameter of 2.2 mm (0.087 inch), a ceramic thermistor core and an outer metallic sheath. The center conductor shall have a maximum diameter of 2.2 mm (0.087 inch). Individual cable sections shall be not greater than 15 m (50 ft) in length and shall be equipped with hermetically sealed connectors. It shall be possible to couple together lengths of cable not greater than 15 m (50 ft) together to form maximum lengths of 305 m (1,000 ft) for individual circuit configurations. The detector shall be able to sense temperatures from 21 up to 649 degrees C (70 up to 1,200 degrees F) and withstand temperature extremes of from -51.1 to 1,093 degrees C (-60 to 2,000 degrees F). The detector cable shall be self-restoring and thus not require replacement of affected portions of the cable after exposure to a high temperature such as would occur in a fire situation. It shall be possible to supervise the cable against an open or short circuit along the entire length of the cable such that either condition will cause a "trouble" signal on the control panel to which it is connected. The cable shall be fully compatible with the control panel to which it is connected.

2.21.5 Combination Ultraviolet-Infrared Flame Detector

Flame detector shall operate on the dual spectrum ultraviolet/infrared (UV-IR) principle. Detector shall utilize a solar-blind UV sensor with a high signal-to-noise ratio and a narrow band IR sensor. Detector logic shall require both UV and IR signals to be present, in a predetermined ratio or signature as emitted by a hydrocarbon fire, to put the detector in an alarm condition. Detector shall not respond to non-fire sources of UV or IR radiation, including intermittent or continuous solar radiation, arc welding, lightning, radiant heat, x-ray, artificial lighting, radio transmissions and jet engine exhaust. Detector shall have an automatic through-the-lens self-testing feature. Malfunction of the detector circuitry, or degradation of the sensors' lens cleanliness to the point where the detector will not detect the design fire signature, shall cause operation of the system trouble alarm. Logic circuits necessary for operation of the detector shall be integral to the detector or located in a separate flame detector control panel mounted adjacent to the foam system control panel. Detector shall have a 120 degrees field-of-view, capable of operating in a temperature range of -40 to 85 degrees C (-40 to 186 degrees F), and suitable for use in Class I, Division I hazardous locations. The detector shall be listed or approved for use with the control panel to which it is connected.

2.21.6 Nozzle System Actuation Station

Unit shall be dual-action type requiring the lifting of a cover and pulling of a ring to actuate. It shall not require the breaking of glass to actuate. Unit shall be painted lime yellow and include a cast or engraved label indicating Foam Nozzle System with operating instructions clearly marked on the station cover. Alarm contacts shall have a minimum rating of 120 VAC, 60 Hz, 6 amps. Contact gap distance shall be factory set and not be field adjustable. Unit shall be compatible with the control panel to which it is connected. If indicated on drawings, unit shall be listed or approved for use in hazardous locations.

2.21.6.1 Enclosure

Unit shall consist of a tamper-resistant, clear polycarbonate shield and frame that fits over the manual actuation station. The unit shall be hinged of the top and suitably labeled "Lift Here" on the bottom to indicate means of gaining access to the manual actuation station it protects. It shall include a spacer as required to accommodate its use with a surface mounted manual actuation station.

2.21.6.2 Horn

The unit shall include an 85 db at 3 m (10 ft) integral horn powered by a 9 VDC alkaline battery. Upon lifting of the cover, the horn shall provide a local supervisory alarm. The enclosure shall be suitably labeled "TO ACTIVATE NOZZLES, LIFT COVER AND OPERATE STATION."

2.22 VALVE SUPERVISORY (TAMPER) SWITCH

Switch shall be designed to monitor the open condition of each water or AFFF concentrate control valve to which it is mounted. It shall include a cast aluminum housing, tamper proof cover, two sets of single pole, double throw (SPDT) contacts and brackets and J-bolts needed for mounting. Removal of the cover shall cause both switches to operate.

2.23 NOTIFICATION APPLIANCES

Notification appliances shall be suitable for connection to supervised alarm indicating circuits. Appliance shall have a separate screw terminal for each conductor.

2.23.1 Electronic Signaling Device

Device shall be surface-mounted type which can be mounted to a standard 100 mm (4 inch) square back box. Electronic device shall operate on nominal 24 VDC, shall be polarized for line supervision and shall have screw terminals for in-out wiring. Device shall be provided with three field-selectable sounds (horn, warble, siren) and three sound output levels to 102 DBA in an anechoic chamber at 3 m (10 fee)t.

2.23.2 Alarm Horn

Horn shall be surface mounted, with the matching mounting back box surface mounted or recessed, grill and vibrating type suitable for use in an electrically supervised circuit. Horns shall operate on nominal 24 VDC and have screw terminals for in-out wiring connection. Sound output shall be a minimum of 85 DBA at 3 m (10 feet). Horns used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grills.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Aboveground Piping

Piping shall be installed straight and bear evenly on hangers and supports. Preaction sprinkler system piping shall be pitched as if it were being installed in areas subject to freezing. Piping shall be concealed in areas with suspended ceiling and shall be inspected, tested and approved before being concealed.

3.1.1.1 Joints

Pipe joints shall conform to NFPA 13. Not more than four threads shall show after joint is made up. Joint compound shall be applied to male threads only. Joints shall be faced true, provided with gaskets and made square and tight. Flanged joints or mechanical groove couplings shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published installation instructions. All grooved couplings and fittings shall be from the same manufacturer. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.1.2 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 13 mm (1/2 inch).

3.1.1.3 Sprinkler Riser Nipples (Sprigs)

Riser nipples (sprigs) 25 mm (1 inch) in size between sprinkler branch lines and individual sprinklers shall not be used unless necessitated by roof or ceiling conditions. In such cases, fittings shall not be installed between the branch line tee and the reducing coupling below the sprinkler.

3.1.1.4 Sprinkler Deflectors

Sprinkler deflectors shall be installed parallel to the roof or ceiling. Deflector distances from the underside of the roof or ceiling shall be in accordance with NFPA 13 except that in no case shall distance exceed 300 mm (12 inches). Sprinkler clearances from obstructions shall be in accordance with NFPA 13.

3.1.1.5 Pipe Supports and Hangers

Installation methods outlined in NFPA 13 are mandatory. Protection of piping against damage from earthquakes shall be provided. Longitudinal and lateral sway bracing shall be provided for piping 65 mm (2-1/2 inch) diameter and larger.

3.1.1.6 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes penetrating concrete or masonry walls or concrete floors shall be provided with pipe sleeves fitted into place at the time of construction through its respective wall or floor, and shall be cut flush with each surface. Sleeve sizes and clearance between pipe and sleeve shall be in accordance with NFPA 13. Where pipes pass through fire walls, fire partitions, or floors, a fire seal shall be placed between the pipe and sleeve in accordance with Section 07 84 00 FIRESTOPPING.

3.1.1.7 Piping Pitch

Piping shall be pitched to the main drain or to auxiliary drains provided as required to facilitate draining. Branch lines shall be pitched at least 4 mm in 1 m (1/2 inch in 10 feet) and cross-mains and feed-mains shall be pitched to at least 2 mm in 1 m (1/4 inch in 10 feet).

3.1.1.8 Escutcheons

Escutcheons shall be provided at finished surfaces where exposed piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe and shall be chromium-plated iron or chromium-plated brass, either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.1.1.9 Drains

Main drain piping shall be provided to discharge at safe points outside each building. Drains shall be of adequate size to readily receive the full flow from each drain under maximum pressure. Auxiliary drains shall be provided as required by NFPA 13 except that drain valves shall be used where drain plugs are otherwise permitted. Where branch lines terminate at low points and form trapped sections, such branch lines shall be manifolded to a common drain line. Each drain valve shall be provided with a metal sign identifying the type of drain connection or function of the valve.

3.1.1.10 Identification Signs

Signs shall be in accordance with NFPA 13. Properly lettered and approved metal signs shall be suitably affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate.

3.2 EXCAVATION, TRENCHING AND BACKFILLING

Earthwork shall be performed in accordance with applicable provisions of Section 31 00 00 EARTHWORK.

3.3 UNDERGROUND PIPING

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be 1 m (3 feet). The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be coated with a bituminous material.

3.4 ELECTRICAL WORK

Unless otherwise specified, power supply equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.4.1 Overcurrent and Surge Protection

Equipment connected to alternating current circuits shall be protected from surges in accordance with IEEE C62.41.1, IEEE C62.41.2 and NFPA 70. Cables and conductors which serve as communication links, except fiber optics, shall have surge protection circuits installed at each end. Fuses shall not be used for surge protection.

3.4.2 Grounding

Grounding shall be provided to building ground.

3.4.3 Wiring

System field wiring shall be installed in 20 mm (3/4 inch) minimum diameter electrical metallic tubing or metallic conduit. Wiring for the sprinkler system fire detection and control system shall be installed in tubing or conduits dedicated for that use only and shall not be installed in conduit, outlet boxes or junction boxes which contain lighting and power wiring or equipment. Circuit conductors entering or leaving any mounting box, outlet box enclosure or cabinet shall be connected to screw terminals with each terminal marked and labeled in accordance with the wiring diagram. No more than one conductor shall be installed under any screw terminal. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors is not permitted. Wiring within any control equipment shall be readily accessible without removing any component parts. Conductors shall be color coded and shall be identified within each enclosure where a connection or termination is made. Conductor identification shall be by plastic coated, self-sticking, printed markers, or by heat-shrink type sleeves. Circuits shall be wired to maintain electrical supervision so that removal of any single wire from any device shall cause a "trouble" condition on the control panel.

3.4.4 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 600 mm (24 inches) nor more than 2000 mm (78 inches) above the finished floor.

3.4.5 Detectors

Detectors shall be ceiling mounted in accordance with NFPA 72 and shall be at least 300 mm (12 inches) from any part of any lighting fixture. Detectors shall be located at least 900 mm (3 feet) from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location.

3.4.6 Manual Actuation Stations

Manual actuation stations shall be mounted readily accessible and 1060 mm (42 inches) above the finished floor.

3.4.7 Notification Appliances

Notification appliances shall be mounted a minimum of 2400 mm (8 feet) above the finished floor unless limited by ceiling height.

3.5 PIPE PAINTING AND LABELING

3.5.1 Painting

Black steel pipe shall be painted in accordance with the requirements specified under SECTION 09 90 00 PAINTS AND COATINGS. Pipe in equipment rooms shall be painted red. Pipe in other areas shall be painted to match finishes in those areas. Stainless steel pipe shall not be painted.

3.5.2 Pipe Identification

Aboveground pipe 50 mm (2 inch) diameter and larger shall be identified with legends. Legends shall include FOAM CONCENTRATE, FOAM-WATER SPRINKLER, FOAM-WATER NOZZLE, and FIRE PROTECTION WATER. Legends shall utilize WHITE letters on a RED color field and shall include arrows to indicate the direction of flow. Length of color field, letter size and locations on piping shall be as recommended in ASME A13.1.

3.6 PRELIMINARY TESTS

Tests shall be performed to make adjustments in the fire protection system operation and to verify that the system will function as intended and that it is ready for service. Such tests shall include all components and subsystems. Test results shall be clearly documented and included with the written request for Final Test.

3.6.1 Flushing

Underground water mains shall be flushed in accordance with NFPA 13 and NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less than the maximum water demand rate of the system.

3.6.2 Hydrostatic Tests

The underground and aboveground piping systems, including AFFF concentrate, shall be hydrostatically tested in accordance with NFPA 13 at not less than 1379 kPa (200 psi), or 345 kPa (50 psi) in excess of maximum system operating pressure, for 2 hours. There shall be no visible leakage from the piping when the system is subjected to the hydrostatic test.

3.6.3 Alarm Check and Automatic Water Control Valves

Each valve shall be tested to verify operation in accordance with manufacturer's published operating instructions. This shall include tests of valves and switches connected thereto.

3.6.4 Nozzles

Nozzles shall be discharge tested for proper operation and coverage. Oscillating nozzles shall be operated to verify that angle of elevation, angle of oscillation, and discharge range, are in accordance with requirements.

3.6.5 AFFF Concentrate System

Tests shall be conducted under the supervision of a technical representative employed by the AFFF concentrate manufacturer. The complete AFFF concentrate system shall be adjusted and tested to assure proper operation. Test results, including all pressure settings and readings, shall be recorded on an appropriate test form signed and dated by manufacturer's representative certifying that the system is in compliance with contract requirements and the manufacturer's recommended practices. Testing shall include, but not be limited to, the following:

a. Filling the AFFF concentrate tank.

b. Adjustment of pressure sustaining valves, pump relief valves, and proportioners.

c. Collection of AFFF samples and testing with a conductivity meter to verify proportioning accuracy.

d. Testing AFFF concentrate pumps for proper automatic operation. This shall include start and stop settings, automatic shutoff, and relief valve operation.

e. Testing low liquid level alarms and pump shutoff.

f. Other operational checks recommended by the AFFF proportioner manufacturer.

3.6.6 Control System Tests

Tests shall be conducted under the supervision of a factory-trained representative of the control panel manufacturer. The electrical control system shall be tested to verify that the control panel and all wiring have been installed correctly and that all components function as intended. Tests shall be conducted using normal operating and battery power. Testing shall include, but not be limited to, each of the following:

a. Alarm initiating circuit and device. This shall include heat detectors, manual actuation stations, waterflow and pressure switches, and similar devices connected to the control panel.

b. Supervisory circuit and device. This shall include valve supervisory (tamper) switches, pump power circuits, pump running, low liquid level in foam concentrate tank, and similar circuits and devices.

c. Actuation circuit and device. This shall include circuits to automatic water control valves, foam concentrate pumps, fire pumps, and similar circuits related to system activation.

d. Annunciator lamp and notification appliance. This shall include bells, horns, electronic signaling, and similar devices.

3.7 FINAL TEST

3.7.1 Requirements

The Final Test shall be a repeat of Preliminary Tests, except that flushing and hydrostatic tests shall not be repeated. In addition, the system shall be automatically actuated and allowed to discharge for a period of at least one minute prior to shutting the system off. Correct system failures and other deficiencies identified during testing and shall retest portions of the system affected by the required corrections.

3.7.1.1 Pretest Requirements

The system will be considered ready for final testing only after the following have been accomplished.

a. The required test plan has been submitted and approved.

b. Preliminary tests have been made and deficiencies determined to have been corrected to the satisfaction of the equipment manufacturer's technical representatives and the Contracting Officer.

c. Test reports, including the required videotape of the preliminary tests, have been submitted and approved.

d. The control panels and detection systems shall have been in service for a break-in period of at least 14 consecutive days prior to the final test.

e. The Contractor has provided written notification to the Contracting Officer, at least 21 days prior to date of Final Test, that preliminary tests have been successfully completed.

3.7.1.2 Videotaping

Videotape the tests in VHS format and record the date and time-lapse, in seconds, from start to finish of each portion of the test as directed by the Contracting Officer. Submit four copies of the tape before the system will be considered accepted.

3.7.1.3 Manufacturer's Services

Experienced technicians regularly employed by the Contractor in the installation of the system and manufacturer's representative referred to elsewhere in this specification shall conduct the testing.

3.7.1.4 Materials and Equipment

Provide AFFF concentrate, gauges, AFFF sample collection apparatus, instruments, hose, personnel, elevating platforms, scaffolding, ladders, appliances and any other equipment necessary to fulfill testing requirements specified.

3.7.1.5 Facility and Environmental Protection

Provide protection for the facility, including electrical and mechanical equipment exposed to possible damage during discharge tests. This shall include provision of sandbags or similar means for preventing migration of foam solution into adjacent areas. Temporary measures shall be provided to prevent AFFF solution from entering storm drains, sanitary sewers, drainage ditches, streams and other water sources. Discharged AFFF shall be contained on paved surfaces and shall not be allowed to come in contact with the earth.

3.7.2 Control System Tests

Operational features of the control system shall be tested and demonstrated. This shall include testing of control panels and each input and output circuit. Tests of circuits shall include actuation and simulated circuit fault at each initiating, notification, supervisory and actuation device or appliance. As a practical matter, these tests shall be a repeat of preliminary tests required under paragraph PRELIMINARY TESTS.

3.7.3 AFFF Proportioning System Tests

Each AFFF proportioner (ratio controller) shall be flow tested to determine that proportioning accuracy is within specified limits. Each proportioner supplying sprinkler systems with closed heads shall be tested at two flow rates; the minimum flow rate specified in the manufacturer's published data and a flow rate at least four times the minimum. Each proportioner supplying a deluge system or a nozzle system shall be tested at the design flow rate. Collecting AFFF samples from each proportioner shall be accomplished in accordance with NFPA 16, and the approved test plan. Foam solution concentrations shall be determined using the methods outlined in NFPA 16. Proportioning for nominal 3 percent concentrate shall be between 3 percent and 4 percent. If test results indicate proportioning below or above this range, make necessary adjustments and retest as directed by the Contracting Officer.

3.7.4 Post-discharge Test Requirements

Following the successful completion of the tests, remove the foam solution from the site as indicated on the approved AFFF waste containment and disposal plan. Replenish AFFF concentrate consumed during the tests. The entire fire protection system shall be returned to automatic operation and the facility restored to operational capability. Discharged solution shall be contained and disposed of in a manner acceptable to local authorities and as identified on the approved test plan. Once tests are completed, systems shall be returned to fully operational status, including filling of AFFF concentrate tanks with concentrate and filling of solution piping with premix as required. Submit details of method proposed for required tests at Final Acceptance, including step-by-step test procedures; list of equipment to be used; names, titles, and affiliations and qualifications of personnel who will participate in the tests; methods for protecting the facility and equipment during testing; means for containing the AFFF solution during discharge tests; and proposed means for disposal. Test plan shall include a drawing showing proposed number and arrangement of fire hoses and nozzles proposed for use in testing foam proportioners. Include blank forms to be used for recording test results. Submit test reports and videotapes as specified herein:

a. Reports as outlined in NFPA 13 documenting results of flushing and hydrostatic tests.

b. Trip tests of alarm check and automatic water control valves.

c. Test report of AFFF concentrate proportioning system. Report shall include all pressure readings and settings of pumps, pressure sustaining valves, relief valves and similar system components. Report shall include conductivity readings for foam samples taken from each AFFF proportioner. Report shall be signed by the factory-trained technical representative employed by the AFFF concentrate manufacturer.

d. Test report of the foam system control panel and initiating and indicating devices. Report shall include a unique identifier for each device with an indication of test results. Report shall be signed by the factory-trained technician employed by the control panel manufacturer.

e. Videotapes of tests specified to be recorded.

3.8 POSTED INSTRUCTIONS

Framed description of system operation, instructions and schematic diagrams of the overall AFFF system and each subsystem, shall be posted where directed. Condensed operating instructions explaining the system for normal operation, refilling the AFFF storage tank, and routine testing shall be included.

3.9 Operation and Maintenance Manuals

Submit one hard copy and one digital copy (.pdf - text searchable) of manuals in loose-leaf binder format and grouped by technical sections consisting of manufacturer's brochures, schematics, printed instructions, general operating procedures, and safety precautions. Manuals shall include a narrative description of the sequence or sequences of operation of the overall fire protection system and a separate description for each major subsystem. Information to be provided shall include specific start/stop settings for pumps, open/close settings for all adjustable valves (including pressure sustaining and relief valves) shall be included. The manuals shall list routine maintenance procedures, possible breakdowns, and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout, simplified wiring and control diagrams for the system as installed, procedures and instructions pertaining to frequency of preventive maintenance, inspection, adjustment, lubrication and cleaning necessary to minimize corrective maintenance and repair.

3.10 TRAINING

Provide at least two training sessions of at least 6 hours each to explain system's operation and maintenance. Training sessions shall be conducted on alternate days to afford flexibility by shift personnel and other attendees. Training aids shall be provided as necessary to clearly describe the systems. Training sessions shall include classroom instruction and explanation of approved Operation and Maintenance Manuals. In addition to classroom instruction, systems shall be operated to provide hands-on demonstrations. Include a system actuation using water only, to demonstrate system operation and procedures for resetting the system. Training areas will be provided by the Government in the building where the systems are installed. Dates and times of the training sessions shall be coordinated with the Contracting Officer not less than 15 calendar days prior to the first session.

-- End of Section --

SECTION 21 21 03.00 10

WET CHEMICAL FIRE EXTINGUISHING SYSTEM
02/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 17A	(2013) Standard for Wet Chemical Extinguishing Systems
NFPA 96	(2014) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

UNDERWRITERS LABORATORIES (UL)

UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 SYSTEM DESCRIPTION

1.2.1 General

Protect each of the following cooking equipment items, including the exhaust hood, grease extractor,grease filter, and exhaust duct serving the item by pre-engineered wet chemical fire extinguishing system. System shall be installed with all accessories necessary for system to operate in accordance with manufacturer's instructions and as specified herein.

1.2.2 Design and Installation Requirements

System application, design, and installation shall comply with NFPA 17A and NFPA 96, except as follows:

a. Compliance shall include conformance to the advisory provisions by changing "should" to "shall."

b. System components shall be listed in UL Fire Prot Dir or approved by FM APP GUIDE for use with wet chemical fire extinguishing systems.

c. Reference to the "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

d. The use of grease extractors does not eliminate the requirement that duct systems, grease removal devices, and hoods be protected by the wet chemical extinguishing system.

1.2.3 System Controls

Each system shall be actuated by fusible link and by a remote manual actuation station connected to the extinguishing system release mechanism by cable. Remote manual actuation stations shall be located along the path of egress and shall automatically actuate the building or base fire alarm system. The system controls shall automatically shut off fuel flow and electrical power to the protected appliances and other appliances located under the ventilating system protected by the extinguishing system upon system actuation. All cables used shall be stainless steel with corner pulleys employing stainless steel ball bearings at all corners. All cable and wiring shall be enclosed in conduit.

1.2.4 Existing Building Fire Alarm Control Panel

Manufacturer's information for the existing building fire alarm control panel is shown on the drawing. The wet chemical fire extinguishing system shall be connected to a spare zone module unless otherwise indicated on drawings.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Similar Services
Standard Products; G

Field Training

SD-06 Test Reports

Preliminary Tests
Final Acceptance Tests

SD-07 Certificates

Installation Technician; G
Installation Drawings; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions

1.4 QUALITY ASSURANCE

Submit a statement demonstrating successful completion of similar services on at least five projects of similar size and scope, at least 2 weeks before submittal of other items required by this section.

1.4.1 Coordination of Trades

Each system shall be coordinated with the equipment, hood, and exhaust ducts that it protects along with other construction in order to eliminate any interference.

1.4.2 Installation Technician

The installation technician shall have been trained by the system manufacturer for system installation, operation, and maintenance. Concurrent with statement of similar services, submit manufacturer's certification of installation technician.

1.4.3 Installation Drawings

Provide installation drawings prepared by a representative of the manufacturer to ensure compliance with the requirements listed herein and with all manufacturer's requirements and recommendations. Submit drawings consisting of system layout including assembly and installation details and electrical connection diagrams; piping layout showing pipe sizes, lengths, and supports. Drawings shall include any information required to demonstrate that the system has been coordinated and will function as intended and shall show system relationship to items it protects and clearances required for operation and maintenance. Submit manufacturer's certification of the drawings. Drawings shall also include conduit, cables, manual actuation stations and fusible links. Include detail drawings for the following items:

a. Storage containers and mounting brackets

b. Fusible links, cables, conduit, corner pulleys, and link mounting frames/brackets

c. Release mechanisms

d. Valves

e. Discharge nozzles

f. Piping components

g. Remote manual actuation stations

h. Fuel and power shutoff

i. Alarms, alarm devices, alarm interface(s), control panels

1.5 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide system components which are the standard products of a manufacturer regularly engaged in the manufacturing of products that are of similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year experience shall include installations of systems under similar circumstances and of similar size.

b. Submit manufacturer's catalog data. The data shall be highlighted to show model, size, options, etc., that are intended for consideration and shall be adequate to demonstrate compliance with contract requirements.

c. Locate identification signs at each remote manual actuation station. Signs shall be fabricated of rigid plastic, red in color, with engraved white letters that are a minimum 6.5 mm (0.25) inches in height. Each sign shall be engraved with "Fire Extinguishing System" and with a brief description of the equipment protected.

d. Replace the fire alarm panel zone identification label with a new label of similar construction which indicates the equipment is connected to the zone module. Discharge of the extinguishing system shall actuate the fire alarm control panel in the same manner as other actuating devices. Extinguishing system wiring shall be supervised in the same manner as other devices connected to the fire alarm system.

2.2 PIPING COMPONENTS

2.2.1 Pipe and Fittings

Pipe and fittings shall be Schedule 40 stainless steel. Stainless steel tubing may be used in accordance with manufacturer's recommendations. Galvanized pipe shall not be used.

2.2.2 Nozzles

Nozzles shall be stainless steel and shall be equipped with an integral strainer to prevent matter inside the distribution piping from clogging the nozzle orifice. Each nozzle orifice shall be provided with a seal to protect the nozzle from clogging by grease or other obstructions. This seal shall detach upon actuation.

2.3 WET CHEMICAL

The wet chemical shall not have an adverse effect on stainless steel during exposure periods of up to 24 hours.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall be performed by the installation technician in accordance with system manufacturer's instructions. Ductwork access doors shall be provided where indicated and at any items requiring service and inspection, including nozzles and fusible links. Ductwork access doors shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.2 PRELIMINARY TESTS

Submit proposed test procedures for preliminary test, at least 2 weeks before the start of related testing. System diagrams that show system layout and typed condensed normal and emergency operating procedures, methods for checking the system for normal, safe operation, and procedures for manual actuation shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed. After installation has been completed, each system shall be actuated by both fusible link and by remote actuation station to demonstrate proper function of all components, including alarms and fuel flow and power shut off. Actuation by fusible link shall be in a manner approved by the system manufacturer. Test containers, pressurized with either nitrogen or air to normal system operating pressure and of the same size as actual operating containers shall be discharged into system. The seals shall release as during normal actuation. After each discharge, the nozzles shall be removed, disassembled, and strainers shall be cleaned. System piping shall be inspected and cleaned as necessary. All functions of system operation shall be verified, including switches, shutdown of fuel and power to appliances protected by the system or served by the same ventilation system, uniform delivery of air or nitrogen, and activation of alarms. Nozzle seals/covers shall be replaced after the preliminary tests are complete. In the event portions of the tests are unsuccessful, repairs shall be made and the entire test repeated until successful. Submit test report for the preliminary tests in booklet form, upon completion of testing. Report shall document test results including repairs and adjustments made, and final test results.

3.3 FINAL ACCEPTANCE TESTS

Submit proposed test procedures and test schedule for final acceptance test, at least 2 weeks before the start of related testing. System shall be actuated by both fusible link and remote manual actuation station and all system functions shall be verified as described in Paragraph PRELIMINARY TESTS using test containers specified for preliminary tests. Each nozzle shall be provided with a plastic container, hose, and hose fitting to capture all wet chemical discharged. All tests or checks recommended by the manufacturer shall also be performed. In the event portions of the tests are unsuccessful, repairs shall be made and the entire test repeated until successful. Nozzle seals/covers shall be replaced after the final acceptance tests are complete. The system shall be returned to normal operating condition after the completion of testing and wet chemical containers expended shall be recharged and verified leak tight. Extinguishing system and equipment and duct protected by the extinguishing shall be cleaned after completion of testing. Any damage shall be repaired by the Contractor. The weight of each storage container shall be recorded before final acceptance test and after test has been completed and containers recharged. Submit test report for the final acceptance tests in booklet form, upon completion of testing. Report shall document test results including repairs and adjustments made, and final test results. The weight of each storage container shall be recorded before final acceptance test and after test has been completed and containers recharged.

3.4 FIELD TRAINING

Submit proposed schedule for field training, at least 2 weeks before the start of related training. Conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for normal working time and shall start after the system is functionally complete and after the Final Acceptance Test. The field instruction shall cover all of the items contained in the approved

Operation and Maintenance Instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system actuation (automatic and manual), recharging, and routine maintenance, at least 2 weeks before field training. The manuals shall include the manufacturer's name, model number, parts list, list of tools and parts that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number). Service organization shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

-- End of Section --

SECTION 21 30 00

FIRE PUMPS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2005) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2010; Addenda 2011) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service

ASME INTERNATIONAL (ASME)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2014; INT 1-47) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2014) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A795/A795M	(2013) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM B135	(2010) Standard Specification for Seamless Brass Tube
ASTM B135M	(2010) Standard Specification for Seamless Brass Tube (Metric)
ASTM B42	(2010) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube

ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C533	(2013) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM F436	(2011) Hardened Steel Washers
ASTM F436M	(2011) Hardened Steel Washers (Metric)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2014) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1963	(2014) Standard for Fire Hose Connections
NFPA 20	(2013) Standard for the Installation of Stationary Pumps for Fire Protection
NFPA 24	(2013) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 37	(2015) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(2010) Program Detail Manual for

	Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Water Based Systems Layout

UNDERWRITERS LABORATORIES (UL)

UL 1247	(2007; Reprint Apr 2014) Diesel Engines for Driving Stationary Fire Pumps
UL 142	(2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 448	(2007; Reprint Jul 2013) Centrifugal Stationary Pumps for Fire-Protection Service
UL 80	(2007; Reprint Jan 2014) Standard for Steel Tanks for Oil-Burner Fuels and Other Combustible Liquids
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS M 1103	(2008) Liquid Chlorine

1.2 SYSTEM DESCRIPTION

a. Except as modified in this Section or on the drawings, install fire pumps in conformance with NFPA 20, NFPA 70, and NFPA 72, including all recommendations and advisory portions, which shall be considered mandatory; this includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification governs. Devices and equipment for fire protection service shall be UL Fire Prot Dir listed or FM APP GUIDE approved. Interpret all reference to the authority having jurisdiction to mean the Contracting Officer.

b. Submit one hard copy and one digital copy of the Fire Pump Installation Drawings consisting of a detailed plan view, detailed elevations and sections of the pump room, equipment and piping, drawn to a scale of not less than 1:20 (1/2 inch = 1 foot). Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Drawings shall indicate equipment, piping, and associated pump equipment to scale. All clearance, such as those between piping and equipment; between equipment and walls, ceiling and floors; and for electrical working distance clearance around all electrical equipment shall be indicated. Drawings shall include a legend identifying all symbols, nomenclatures, and abbreviations. Drawings shall indicate a complete piping and equipment layout including elevations and/or section views of the following:

1. Fire pumps, controllers, piping, valves, and associated equipment.

2. Sensing line for each pump including the pressure maintenance pump.

3. Engine fuel system for diesel driven pumps.

4. Engine cooling system for diesel driven pumps.

5. Pipe hangers and sway bracing including support for diesel muffler and exhaust piping.

6. Restraint of underground water main at entry-and exit-points to the building including details of pipe clamps, tie rods, mechanical retainer glands, and thrust blocks.

7. A one-line schematic diagram indicating layout and sizes of all piping, devices, valves and fittings.

8. A complete point-to-point connection drawing of the pump power, control and alarm systems, as well as interior wiring schematics of each controller.

c. Tank supports, piping offsets, fittings, and any other accessories required shall be furnished as specified to provide a complete installation and to eliminate interference with other construction.

d. Show detail plan view of the pump room including elevations and sections showing the fire pumps, associated equipment, and piping. Submit working drawings prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES; include data for the proper installation of each system. Show piping schematic of pumps, devices, valves, pipe, and fittings. Provide an isometric drawing of the fire pump and all associated piping. Show point to point electrical wiring diagrams. Show piping layout and sensing piping arrangement. Show engine fuel and cooling system. Include:

(1) Pumps, drivers, and controllers

(2) Hose valve manifold test header

(3) Circuit diagrams for pumps

(4) Wiring diagrams of each controller

e. Post operating instructions for pumps, drivers, controllers, and flow meters.

f. Fully enclose or properly guard coupling, rotating parts, gears, projecting equipment, etc. so as to prevent possible injury to persons that come in close proximity of the equipment. Conduct testing of the fire pumps in a safe manner and ensure that all equipment is safely secured. Hoses and nozzles used to conduct flow tests shall be in excellent condition and shall be safely anchored and secured to prevent any misdirection of the hose streams.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

One hard copy and one digital copy of the Fire Pump Installation Drawings consisting of a detailed plan view, detailed elevations and sections of the pump room, equipment and piping, drawn to a scale of not less than 1:20 (1/2 inch = 1 foot). Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Drawings shall indicate equipment, piping,and associated pump equipment to scale. All clearance, such as those between piping and equipment; between equipment and walls, ceiling and floors; and for electrical working distance clearance around all electrical equipment shall be indicated. Drawings shall include a legend identifying all symbols, nomenclatures, and abbreviations. Drawings shall indicate a complete piping and equipment layout including elevations and/or section views of the following:

a. Fire pumps, controllers, piping, valves, and associated equipment.

b. Sensing line for each pump including the pressure maintenance pump.

c. Engine fuel system for diesel driven pumps.

d. Engine cooling system for diesel driven pumps.

e. Pipe hangers and sway bracing including support for diesel muffler and exhaust piping.

f. Restraint of underground water main at entry-point or entry-and exit-points to the building including details of pipe clamps, tie rods, mechanical retainer glands, and thrust blocks.

g. A one-line schematic diagram indicating layout and sizes of all piping, devices, valves and fittings.

h. A complete point-to-point connection drawing of the pump power, control and alarm systems, as well as interior wiring schematics of each controller.

As-Built Drawings; G

As-Built Drawings, no later than 14 days after completion of the Final Tests. The Fire Pump Installation Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

Piping Layout and Sensing Piping Arrangement; G

Pump Room; G

SD-03 Product Data

Fire Pump Installation Related Submittals; G

A list of the Fire Pump Installation Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist and the Manufacturer's Representative.

Catalog Data; G

Manufacturer's catalog data included with the Fire Pump Installation Drawings for each separate piece of equipment proposed for use in the system. Catalog data shall indicate the name of the manufacturer of each item of equipment, with data annotated to indicate model to be provided. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Spare Parts; G

Spare parts data for each different item of material and equipment specified.

Field Training; G

Proposed schedule for field training submitted at least 14 days prior to the start of related training.

SD-06 Test Reports

Field Tests; G

Proposed diagrams, at least 2 weeks prior to start of related testing.

Preliminary Tests; G

Proposed procedures for Preliminary Tests, at least 14 days prior to the proposed date and time to begin Preliminary Tests.

Preliminary Tests Report; G

One hard copy and one digital copy (.pdf - text searchable) of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests. The Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist and the Manufacturer's Representative.

Army Final Acceptance Test; G

Acceptance Procedures and proposed date and time to begin Army

Final Acceptance Test at least 14 days prior to the proposed start of the test.

Army Final Acceptance Test Report; G

One hard copy & one digital copy (.pdf - text searchable) of the completed Army Final Acceptance Test Reports, no later that 7 days after the completion of the tests. All items in the reports shall be signed by the Fire Protection Specialist and the Manufacturer's Representative.

SD-07 Certificates

Fire Protection Specialist; G

Name and documentation of qualifications of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the fire pump installation drawings.

Certification of Installation; G

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the fire pump installation is in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

Qualifications of Welders; G

Certificates of each welder's qualifications prior to site welding

Qualifications of Installer; G

Certification showing that the Contractor has successfully installed fire pumps and associated equipment of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having such required experience. Certification shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems.

Manufacturer's Representative; G

The name and documentation of certification of the proposed Manufacturer's Representative, concurrent with submittal of the Fire Protection Specialist Qualifications.

Preliminary Test Certification; G

Signed and dated certificate with a request for a formal inspection and tests.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G

One hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Data Package 3 shall be submitted for fire pumps and drivers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

Flow Meter; G

Data Package 2 for flow meter and controllers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.4 QUALITY ASSURANCE

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

1.4.1 Fire Protection Specialist

Work specified in this section shall be performed under the supervision of and certified by the Fire Protection Specialist. Submit the name and documentation of qualifications of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the fire pump installation drawings. The Fire Protection Specialist shall be a registered professional engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES), is in a related engineering discipline with a minimum of 5 years experience dedicated to fire protection engineering that can be verified with documentation, or who is certified as a Level III or IV Technician by the National Institute for Certification in Engineering Technologies (NICET) in the Water Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.2 Qualifications of Welders

Submit certificates of each welder's qualifications prior to site welding; certifications shall not be more than one year old.

1.4.3 Qualifications of Installer

Prior to installation, submit certification showing that the Contractor has successfully installed fire pumps and associated equipment of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having such required experience. Certification shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system and certify that each system has performed satisfactorily in the manner intended for a period of not less than 18 months.

1.4.4 Preliminary Test Certification

When preliminary tests have been completed and corrections made, submit a signed and dated certificate with a request for a formal inspection and tests.

1.4.5 Manufacturer's Representative

Work specified in this section shall be performed under the supervision of and certified by a representative of the fire pump manufacturer. Submit the name and documentation of certification of the proposed Manufacturer's Representative, concurrent with submittal of the Fire Protection Specialist Qualifications. The Manufacturer's Representative shall be regularly engaged in the installation of the type and complexity of fire pump(s) specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall be either capped or plugged until installed.

1.6 SEQUENCING

1.6.1 Primary Fire Pump

Primary fire pump shall automatically operate when the pressure drops to 758 kPa (110 psi), automatically upon tripping of the sprinkler system, or manually when the starter is operated. A running period timer set for at least 10 minutes running time shall commence at initial operation. The fire pump shall automatically stop operating when the system pressure reaches 862 kPa (125 psi)and after the fire pump has operated for the minimum pump run time specified herein. Pump(s) shall automatically shut down after all starting and running causes have returned to normal or upon total exhaustion of suction reservoir water, if applicable. Pumps shall also be equipped with automatic periodic exercise timers to facilitate required preventive maintenance run times of 20 minutes.

1.6.2 Secondary Fire Pump

Secondary fire pump shall operate at 69 kPa (10 psi) increments, set below the primary fire pump starting pressure. The fire pump shall automatically stop running at 862 kPa (125 psi) and after the fire pump has operated for the minimum pump run time. Fire pumps shall be prevented from starting simultaneously and shall start sequentially at intervals of 5 to 10 seconds.

1.6.3 Pressure Maintenance Pump

Pressure maintenance pump shall operate when the system pressure drops to 793 kPa (115 psi). Pump shall automatically stop when the system pressure reaches 862 kPa (125 psi) and after the pump has operated for the minimum pump run time specified herein.

1.7 EXTRA MATERIALS

Submit Spare Parts data for each different item of equipment and material specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

a. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

b. Submit manufacturer's catalog data included with the Fire Pump Installation Drawings for each separate piece of equipment proposed for use in the system. Catalog data shall indicate the name of the manufacturer of each item of equipment, with data annotated to indicate model to be provided. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided. Catalog data for material and equipment shall include, but not be limited to, the following:

1. Fire pumps, drivers and controllers including manufacturer's certified shop test characteristic curve for each pump. Shop test curve may be submitted after approval of catalog data but shall be submitted prior to the final tests.

2. Pressure maintenance pump and controller.

3. Piping components.

4. Valves, including gate, check, globe and relief valves.

5. Gauges.

6. Hose valve manifold test header and hose valves.

7. Flow meter.

8. Restrictive orifice union.

9. Associated devices and equipment.

c. All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, contract number and accepted date; capacity or size; system in which installed and system which it controls and catalog number. Pumps and motors shall have standard nameplates securely affixed in a conspicuous place and easy to read. Fire pump shall have nameplates and markings in accordance with UL 448. Diesel driver shall have nameplate and markings in accordance with UL 1247. Electric motor nameplates shall provide the minimum information required by NFPA 70, Section 430-7.

2.2 FIRE PUMP

Fire pump shall be electric motor driven or diesel engine driven. Each pump capacity shall be as indicated on the drawing. Fire pump shall furnish not less than 150 percent of rated flow capacity at not less than 65 percent of rated net pressure. Pump shall be centrifugal horizontal split case or water lubricated, vertical shaft turbine or end-suction or in-line fire pump. Horizontal pump shall be equipped with automatic air release devices. The maximum rated pump speed shall be 2100 rpm when driving the pump at rated capacity. Pump shall be automatic start and manual stop or manual pushbutton start and stop or automatic start and automatic stop. Pump shall conform to the requirements of UL 448. Fire pump discharge and suction gauges shall be oil-filled type.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

2.3.1 General Requirements

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE.

2.3.2 Alarms

Provide audible and visual alarms as required by NFPA 20 on the controller. Provide remote supervision as required by NFPA 20, in accordance with NFPA 72. Provide remote alarm devices located where indicated on drawings. Alarm signal shall be activated upon the following conditions: electric motor controller has operated into a pump running condition; loss of electrical power to electric motor starter; phase reversal on line side of motor starter; engine drive controller has operated into an engine running condition; engine drive controller main switch has been turned to OFF or to MANUAL position; or trouble on engine driven controller or engine. Exterior alarm devices shall be weatherproof type. Provide alarm silencing switch and red signal lamp, with signal lamp arranged to come on when switch is placed in OFF position.

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe and Fittings

Provide outside-coated, cement mortar-lined, ductile-iron pipe (with a rated working pressure of between 1034 and 1207 kPa (150 and 175 psi) conforming to NFPA 24 for piping under the building and less than 1.50 m (5 feet) outside of the building walls. Anchor the joints in accordance with NFPA 24; provide concrete thrust block at the elbow where the pipe turns up toward the floor, and restrain the pipe riser with steel rods from the elbow to the flange above the floor. Minimum pipe size shall be 150 mm (6 inches). Minimum depth of cover shall be as required by NFPA 24, but no less than 1 m (3 feet). Piping more than 1.50 m (5 feet) outside of the building walls shall be outside coated, AWWA C104/A21.4 cement mortar-lined, AWWA C151/A21.51 ductile-iron pipe, and AWWA C110/A21.10 fittings conforming to NFPA 24.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to AWWA C110/A21.10. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to AWWA C111/A21.11.

2.4.3 Valves and Valve Boxes

Valves shall be gate valves conforming to AWWA C500 or UL 262. Valves shall have cast-iron body and bronze trim. Valve shall open by counterclockwise rotation. Except for post indicator valves, all underground valves shall be provided with an adjustable cast-iron or ductile iron valve box of a size suitable for the valve on which the box is to be used, but not less than 133 mm (5.25 inches) in diameter. The box shall be coated with bituminous coating. A cast-iron or ductile-iron cover with the word "WATER" cast on the cover shall be provided for each box.

2.4.4 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counterclockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be provided with one coat of primer and two coats of red enamel paint and shall be listed in UL Fire Prot Dir or FM APP GUIDE.

2.4.5 Buried Utility Warning and Identification Tape

Detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping shall be provided for all buried piping. Tape shall be detectable by an electronic detection instrument. Tape shall be provided in rolls, 80 mm (3 inches) minimum width, color-coded for the utility involved and imprinted in bold black letters continuously and repeatedly over the entire tape length. Warning and identification shall be "CAUTION BURIED WATER PIPING BELOW" or similar wording. Code and lettering shall be permanent and unaffected by moisture and other substances contained in the trench backfill material. Tape shall be buried at a depth of 300 mm (12 inches) below the top surface of earth or the top surface of the subgrade under pavement.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Pipe Sizes 65 mm (2.5 inches) and Larger

2.5.1.1 Pipe

Piping shall be ASTM A53/A53M or ASTM A795/A795M, Weight Class STD (Standard), Schedule 40 (except for Schedule 30 for pipe sizes 200 mm (8 inches) and greater in diameter), Type E or Type S, Grade A; black steel pipe. Steel pipe shall be joined by means of flanges welded to the pipe or mechanical grooved joints only. Piping shall not be jointed by welding or weld fittings. Suction piping shall be galvanized on the inside in accordance with NFPA 20.

2.5.1.2 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated.

2.5.1.3 Flanges

Flanges shall be ASME B16.5, Class 150 flanges. Flanges shall be provided at valves, connections to equipment, and where indicated.

2.5.1.4 Gaskets

Gaskets shall be AWWA C111/A21.11, cloth inserted red rubber gaskets.

2.5.1.5 Bolts

Bolts shall be ASTM A449, Type 1 or 2 or ASTM A193/A193M, Grade B7. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

2.5.1.6 Nuts

Nuts shall be ASTM A194/A194M, Grade 7, ASTM A193/A193M, Grade 5, or ASTM A563M (ASTM A563), Grade C3 or DH3.

2.5.1.7 Washers

Washers shall meet the requirements of ASTM F436M (ASTM F436). Flat circular washers shall be provided under all bolt heads and nuts.

2.5.2 Piping Sizes 50 mm (2 inches) and Smaller

2.5.2.1 Steel Pipe

Steel piping shall be ASTM A795/A795M, Weight Class STD (Standard), Schedule 40, Type E or Type S, Grade A, ASTM A53/A53M, Weight Class XS (Extra Strong), or KS D 3562, zinc-coated steel pipe with threaded end connections. Fittings shall be ASME B16.3 or ASME B16.39, Class 150, zinc-coated threaded fittings. Unions shall be ASME B16.39, Class 150, zinc-coated unions.

2.5.2.2 Copper Tubing

Copper tubing shall be ASTM B88M (ASTM B88), Type L or K, soft annealed. Fittings shall be ASME B16.26, flared joint fittings. Pipe nipples shall be ASTM B42 copper pipe with threaded end connections.

2.5.3 Pipe Hangers and Supports

Pipe hangers and support shall be MSS SP-58, UL listed UL Fire Prot Dir or FM approved FM APP GUIDE and shall be the adjustable type. Finish of rods, nuts, washers, hangers, and supports shall be zinc-plated after fabrication.

2.5.4 Valves

Valves shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire protection service. Valves shall have flange or threaded end connections.

2.5.4.1 Gate Valves and Control Valves

Gate valves and control valves shall be outside screw and yoke (O.S.&Y.) type which open by counterclockwise rotation. Butterfly-type control valves are not permitted.

2.5.4.2 Tamper Switch

The suction control valves, the discharge control valves, valves to test header and flow meter, and the by-pass control valves shall be equipped with valve tamper switches for monitoring by the fire alarm system.

2.5.4.3 Check Valve

Check valve shall be clear open, swing type check valve with flange or threaded inspection plate.

2.5.4.4 Relief Valve

Relief valve shall be pilot operated or spring operated type conforming to NFPA 20. A means of detecting water motion in the relief lines shall be provided where the discharge is not visible within the pump house.

2.5.4.5 Circulating Relief Valve

An adjustable circulating relief valve shall be provided for each fire pump in accordance with NFPA 20.

2.5.4.6 Suction Pressure Regulating Valve

Suction pressure regulating valve shall be FM approved FM APP GUIDE. Suction pressure shall be monitored through a pressure line to the controlling mechanism of the regulating valve. Valve shall be arranged in accordance with the manufacturer's recommendations.

2.5.5 Hose Valve Manifold Test Header

Construct header of steel pipe. Provide ASME B16.5, Class 150 flanged inlet connection to hose valve manifold assembly. Provide approved bronze hose gate valve with 65 mm (2.5 inch) National Standard male hose threads with cap and chain; locate one meter (3 feet) above grade in the horizontal position for each test header outlet. Welding shall be metallic arc process in accordance with ASME B31.1.

2.5.6 Pipe Sleeves

A pipe sleeve shall be provided at each location where piping passes entirely through walls, ceilings, roofs, and floors, including pipe entering buildings from the exterior. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, and floors. Provide 25 mm (one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, a fire seal shall be provided between the pipe and the sleeve in accordance with Section 07 84 00 FIRESTOPPING.

a. Sleeves in Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron pipe sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves provided that cavities in the core-drilled hole be completely grouted smooth.

b. Sleeves in Other Than Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide galvanized steel sheet pipe not less than 4.4 kg/square m (0.90 psf).

2.5.7 Escutcheon Plates

Provide one-piece or split-hinge metal plates for piping entering floors, walls, and ceilings in exposed areas. Provide polished stainless steel or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on plates in unfinished spaces. Plates shall be secured in place.

2.6 DISINFECTING MATERIALS

2.6.1 Liquid Chlorine

Liquid chlorine shall conform to AWWA B301 or KS M 1103.

2.6.2 Hypochlorites

Calcium hypochlorite and sodium hypochlorite shall conform to AWWA B300.

2.7 ELECTRIC MOTOR DRIVER

Motors, controllers, contactors, and disconnects shall be provided with their respective pieces of equipment, as specified herein and shall have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Controllers and contactors shall have a maximum of 120-volt control circuits, and auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section. Motor shall conform to NEMA MG 1 Design B type. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Motor wattage (horsepower) shall be of sufficient size so that the nameplate wattage (horsepower) rating will not be exceeded throughout the entire published pump characteristic curve. The motor and fire pump controller shall be fully compatible.

2.8 DIESEL ENGINE DRIVER

Diesel engine driver shall conform to the requirements of UL 1247 and shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire pump service. Driver shall be of the make recommended by the pump manufacturer. The engine shall be closed circuit, liquid-cooled with raw water heat exchanger or with radiator and engine-driven fan. Diesel engine shall be electric start type taking current from 2 battery units. Engine shall be equipped with a fuel in-line filter-water separator. Engine conditions shall be monitored with engine instrumentation panel that has a tachometer, hour meter, fuel pressure gauge, lubricating oil pressure gauge, water temperature gauge, and ammeter gauge. Engine shall be connected to horizontal-shaft pump by flexible couplings. For connections to vertical-shaft fire pumps, right-angle gear drives and universal joints shall be used. An engine jacket water heater shall be provided to maintain a temperature of 49 degrees C (120 degrees F) in accordance with NFPA 20.

2.8.1 Engine Capacity

Engine shall have adequate wattage (horsepower) to drive the pump at all conditions of speed and load over the full range of the pump performance curve. The wattage (horsepower) rating of the engine driver shall be as recommended by the pump manufacturer and shall be derated for temperature and elevation in accordance with NFPA 20. Ambient temperature at the pump location shall be as indicated on drawing.

2.8.2 Exhaust System External to Engine

Exhaust system shall comply with the requirements of NFPA 20 and NFPA 37. An exhaust muffler shall be provided for each diesel engine driver to reduce noise levels less than 85 or 95 dBA. A flexible connector with flange connections shall be provided at the engine. Flexible sections shall be stainless steel suitable for diesel-engines exhaust gas at 538 degrees C (1000 degrees F).

2.8.2.1 Steel Pipe and Fittings

ASTM A53/A53M, Schedule 40 or Weight Class XS (Extra Strong), black steel, welding end connections. ASME B16.9 or ASME B16.11 welding fittings shall be of the same material and weight as the piping.

2.8.2.2 Flanges

ASME B16.5, Class 300 or 150. Flanges shall be provided at connections to diesel engines, exhaust mufflers, and flexible connections. Gaskets shall be ASME B16.21, composition ring, 1.5875 mm (0.0625 inch). ASTM A193/A193M, Grade B8 or B7 bolts and ASTM A194/A194M, Grade 8 or 7 nuts shall be provided.

2.8.2.3 Piping Insulation

Products containing asbestos will not be permitted. Exhaust piping system including the muffler shall be insulated with ASTM C533 calcium silicate insulation, minimum of 75 mm (3 inches). Insulation shall be secured with not less than 9.525 mm (0.375 inch) width fibrous glass reinforced waterproof tape or Type 304 stainless steel bands spaced not more than 200 mm (8 inches) on center. An aluminum jacket encasing the insulation shall be provided. The aluminum jacket shall have a minimum thickness of 0.406 mm (0.016 inches), a factory-applied polyethylene and kraft paper moisture barrier on the inside surface. The jacket shall be secured with not less than 13 mm (0.5 inch) wide stainless steel bands, spaced not less than 200 mm (8 inches) on centers. Longitudinal and circumferential seams of the jacket shall be lapped not less than 75 mm (3 inches). Jackets on horizontal line shall be installed so that the longitudinal seams are on the bottom side of the pipe. The seams of the jacket for the vertical lines shall be placed on the off-weather side of the pipe. On vertical lines, the circumferential seams of the jacket shall overlap so the lower edge of each jacket overlaps the upper edge of the jacket below.

2.9 FIRE PUMP CONTROLLER

Controller shall be the automatic type and UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire pump service. Pump shall be arranged for automatic start and stop, and manual push-button stop. Automatic stopping shall be accomplished only after all starting causes have returned to normal and after a minimum pump run time has elapsed. Controllers shall be completely terminally wired, ready for field connections, and mounted in a NEMA Type 2 drip-proof or NEMA Type 4 watertight and dust tight enclosure arranged so that controller current carrying parts will not be less than 300 mm (12 inches) above the floor. Controller shall be provided with voltage surge arresters installed in accordance with NFPA 20. Controller shall be equipped with a bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments, automatic starting relay actuated from normally closed contacts, visual alarm lamps and supervisory power light. Controller shall be equipped with a thermostat switch with adjustable setting to monitor the pump room temperature and to provide an alarm when temperatures falls below 5 degrees C (40 degrees F) Controller shall be equipped with a sequential start timer/relay feature to start multiple fire pumps in sequence. The controller shall be factory-equipped with a heater operated by thermostat to prevent moisture in the cabinet.

2.9.1 Controller for Electric Motor Driven Fire Pump

Controller type shall be as indicated on drawing. Controller shall be designed for power and voltage as indicated on drawings. Controller and transfer switch shall have a short circuit rating as indicated on drawing. An automatic transfer switch (ATS) shall be provided for each fire pump. The ATS shall comply with NFPA 20 and shall be specifically listed for fire pump service. The ATS shall transfer source of power to the alternate source upon loss of normal power. Controller shall monitor pump running, loss of a phase or line power, phase reversal, low reservoir and pump room temperature. Alarms shall be individually displayed in front of panel by lighting of visual lamps. Each lamp shall be labeled with rigid etched plastic labels. Controller shall be equipped with terminals for remote monitoring of pump running, pump power supply trouble (loss of power or phase and phase reversal), and pump room trouble (pump room temperature and low reservoir level), and for remote start. Limited service fire pump controllers are not permitted, except for fire pumps driven by electric motors rated less than 11 kW (15 hp). Controller shall be equipped with a 7-day electric pressure recorder with 24-hour spring wound back-up. The pressure recorder shall provide a readout of the system pressure from 0 to 207 Pa (0 to 15 hp), time, and date. Controller shall require the pumps to run for ten minutes for pumps with driver motors under 149 kW (200 horsepower) and for 15 minutes for pumps with motors 149 kW (200 horsepower) and greater, prior to automatic shutdown. The controller shall be equipped with an externally operable isolating switch which manually operates the motor circuit. Means shall be provided in the controller for measuring current for all motor circuit conductors.

2.9.2 Controller for Diesel Engine Driven Fire Pump

Controller shall require the pump to run for 30 minutes prior to automatic shutdown. Controller shall be equipped with two battery chargers; two ammeters; two voltmeters, one for each set of batteries. Controller shall automatically alternate the battery sets for starting the pumps. Controller shall be equipped with the following supervisory alarm functions:

a. Engine Trouble (individually monitored)

(1) Engine overspeed

(2) Low Oil Pressure

(3) High Water Temperature

(4) Engine Failure to Start

(5) Battery

(6) Battery Charger/AC Power Failure

b. Main Switch Mis-set

c. Pump Running

d. Pump Room Trouble (individually monitored)

(1) Low Fuel

(2) Low Pump Room Temperature

(3) Low Reservoir Level

Alarms shall be individually displayed in front of panel by lighting of visual lamps, except that individual lamps are not required for pump running and main switch mis-set. Controller shall be equipped with a 7-day electric pressure recorder with 24-hour back-up mounted inside the controller. The pressure recorder shall provide a readout of the system pressure from 0 to 207 Pa (0 to 300 psi), time, and date. The controller shall be equipped with an audible alarm which will activate upon any engine trouble or pump room trouble alarm condition and alarm silence switch. Controller shall be equipped with terminals for field connection of a remote alarm for main switch mis-set, pump running, engine trouble and pump room trouble; and terminals for remote start. When engine emergency overspeed device operates, the controller shall cause the engine to shut down without time delay and lock out until manually reset.

2.10 BATTERIES

Batteries for diesel engine driver shall be sealed lead calcium batteries. Batteries shall be mounted in a steel rack with non-corrosive, non-conductive base, not less than 300 mm (12 inches) above the floor.

2.11 PRESSURE SENSING LINE

A completely separate pressure sensing line shall be provided for each fire pump and for the jockey pump. The sensing line shall be arranged in accordance with Figure A-7-5.2.1. of NFPA 20. The sensing line shall be 13 mm (1/2 inch) H58 brass tubing complying with ASTM B135M (ASTM B135). The sensing line shall be equipped with two restrictive orifice unions each. Restricted orifice unions shall be ground-face unions with brass restricted diaphragms drilled for a 2.4 mm (3/32 inch). Restricted orifice unions shall be mounted in the horizontal position, not less than 1.5 m (5 feet) apart on the sensing line. Two test connections shall be provided for each sensing line. Test connections shall consist of two brass 13 mm (1/2 inch) globe valves and 8 mm (1/4 inch) gauge connection tee arranged in accordance with NFPA 20. One of the test connections shall be equipped with a 0 to 2100 kPa (0 to 300 psi) water oil-filled gauge. Sensing line shall be connected to the pump discharge piping between the discharge piping control valve and the check valve.

2.12 PRESSURE MAINTENANCE PUMP

2.12.1 General

Pressure maintenance pump shall be electric motor driven, horizontal shaft or in-line vertical shaft, centrifugal type with a rated discharge of 0.63 L/second (10 gpm) at 862 kPa (125 psig). Pump shall draft from the suction supply side of the suction pipe gate valve of the fire pump or as indicated on drawings and shall discharge into the system at the downstream side of the pump discharge gate valve. An approved indicating gate valve of the outside screw and yoke (O.S.&Y.) type shall be provided in the maintenance pump discharge and suction piping. Oil-filled water pressure gauge and approved check valve in the maintenance pump discharge piping shall be provided. Check valve shall be swing type with removable inspection plate.

2.12.2 Pressure Maintenance Pump Controller

Pressure maintenance pump controller shall be arranged for automatic and manual starting and stopping and equipped with a "manual-off-automatic" switch. The controller shall be completely prewired, ready for field connections, and wall-mounted in a NEMA Type 2 drip-proof enclosure. The controller shall be equipped with a bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments for automatic starting and stopping. A sensing line shall be provided connected to the pressure maintenance pump discharge piping between the control valve and the check valve. The sensing line shall conform to paragraph, PRESSURE SENSING LINE. The sensing line shall be completely separate from the fire pump sensing lines. An adjustable run timer shall be provided to prevent frequent starting and stopping of the pump motor. The run timer shall be set for 2 minutes.

2.13 DIESEL FUEL SYSTEM EXTERNAL TO ENGINE

Fuel system shall be provided that meets all requirements and advisory provisions of NFPA 20 and NFPA 37. The fuel tank vent piping shall be equipped with screened weatherproof vent cap. Vents shall be extended to the outside. Each tank shall be equipped with a fuel level gauge. Flexible bronze or stainless steel piping connectors with single braid shall be provided at each piping connection to the diesel engine. Supply, return, and fill piping shall be steel piping, except supply and return piping may be copper tubing. Fuel lines shall be protected against mechanical damage. Fill line shall be equipped with 16 mesh removable wire screen. Fill lines shall be extended to the exterior. A weatherproof tank gauge shall be mounted on the exterior wall near each fill line for each tank. The fill cap shall be able to be locked by padlock. The engine supply (suction) connection shall be located on the side of the fuel tank so that 5 percent of the tank volume provides a sump volume not useable by the engine. The elevation of the fuel tank shall be such that the inlet of the fuel supply line is located so that its opening is no lower than the level of the engine fuel transfer pump. The bottom of the tank shall be pitched 21 mm/m (1/4 inch/foot) to the side opposite the suction inlet connection, and to an accessible 25 mm (1 inch) plugged globe drain valve.

2.13.1 Steel pipe

ASTM A53/A53M, hot-dipped zinc-coated, Schedule 40, threaded connections. Fittings shall be ASME B16.3, zinc-coated, threaded malleable iron fittings. Unions shall be ASME B16.39 zinc-coated, threaded unions.

2.13.2 Diesel Fuel Tanks

UL 80 or UL 142 for aboveground tanks.

2.13.3 Valves

An indicating and lockable ball valve shall be provided in the supply line adjacent to the tank suction inlet connection. A check valve shall be provided in fuel return line. Valves shall be suitable for oil service. Valves shall have union end connections or threaded end connections.

a. Globe valve: MSS SP-80 Class 125

b. Check valve: MSS SP-80, Class 125, swing check

c. Ball valve: Full port design, copper alloy body, 2-position lever handle.

2.14 PUMP BASE PLATE AND PAD

A common base plate shall be provided for each horizontal-shaft fire pump for mounting pump and driver unit. The base plate shall be constructed of cast iron with raised lip tapped for drainage or welded steel shapes with suitable drainage. Each base plate for the horizontal fire pumps shall be provided with a 25 mm (1 inch)galvanized steel drain line piped to the nearest floor drain. For vertical shaft pumps, pump head shall be provided with a cast-iron base plate and shall serve as the sole plate for mounting the discharge head assembly. Pump units and bases shall be mounted on a raised 100 or 150 mm (4or 6 inches) reinforced concrete pad that is an integral part of the reinforced concrete floor.

2.15 HOSE VALVE MANIFOLD TEST HEADER

Hose valve test header shall be connected by ASME B16.5, Class 150 flange inlet connection. Hose valves shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE bronze hose gate valves with 65 mm (2.5 inches) American National Fire Hose Connection Screw Standard Threads (NH) in accordance with NFPA 1963. The number of valves shall be in accordance with NFPA 20. Each hose valve shall be equipped with a cap and chain, and located no more than 900 mm (3 feet) and no less than 600 mm (2 feet) above grade.

2.16 FLOW METER

Meter shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE as flow meters for fire pump installation with direct flow readout device. Flow meter shall be capable of metering any water flow quantities between 50 percent and 150 percent of the rated flow of the pumps. Submit Data Package 2 for flow meter and controllers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Arrange piping to permit flow meter to discharge to pump suction and to discharge through test header. The meter throttle valve and the meter control valves shall be O.S.&Y. valves. Provide automatic air release if flow meter piping between pump discharge and pump suction forms an inverted "U". Meter shall be of the venturi, annular probe, or orifice plate type.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 FIRE PUMP INSTALLATION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals, from the Contract Submittal Register, that relate to the successful installation of the fire pump(s), no later than 7 days after the approval of the Fire Protection Specialist and the Manufacturer's Representative. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

3.3 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall periodically perform a thorough inspection of the fire pump installation, including visual observation of the pump while running, to assure that the installation conforms to the contract requirements. There shall be no excessive vibration, leaks (oil or water), unusual noises, overheating, or other potential problems. Inspection shall include piping and equipment clearance, access, supports, and guards. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered. The Fire Protection Specialist shall witness the preliminary and final acceptance tests and, after completion of the inspections and a successful final acceptance test, shall sign test results and certify in writing that the installation the fire pump installation is in accordance with the contract requirements.

3.4 INSTALLATION REQUIREMENTS

Carefully remove materials so as not to damage material which is to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction. Equipment, materials, workmanship, fabrication, assembly, erection, installation, examination, inspection and testing shall be in accordance NFPA 20, except as modified herein. In addition, the fire pump and engine shall be installed in accordance with the written instructions of the manufacturer.

3.5 PIPE AND FITTINGS

Piping shall be inspected, tested and approved before burying, covering, or concealing. Fittings shall be provided for changes in direction of piping and for all connections. Changes in piping sizes shall be made using tapered reducing pipe fittings. Bushings shall not be used. Photograph all piping prior to burying, covering, or concealing.

3.5.1 Cleaning of Piping

Interior and ends of piping shall be clean and free of any water or foreign material. Piping shall be kept clean during installation by means of plugs or other approved methods. When work is not in progress, open ends of the piping shall be securely closed so that no water or foreign matter will enter the pipes or fittings. Piping shall be inspected before placing in position.

3.5.2 Threaded Connections

Jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread tape conforming to ASTM D3308 or Teflon pipe thread paste and shall be applied to male threads only. Exposed ferrous pipe threads shall be provided with one coat of zinc molybdate primer applied to a minimum of dry film thickness of 0.025 mm (1 mil).

3.5.3 Pipe Hangers and Supports

Additional hangers and supports shall be provided for concentrated loads in aboveground piping, such as for valves and risers.

3.5.3.1 Vertical Piping

Piping shall be supported at each floor, at not more than 3 meters (10 foot) intervals.

3.5.3.2 Horizontal Piping

Horizontal piping supports shall be spaced as follows:

MAXIMUM SPACING (METERS)

Nominal Pipe Size (mm)	25 and Under	32	40	50	65	80	90	100	125	150+
Steel Pipe	2	2.4	2.7	3	3.3	3.6	3.9	4.2	4.8	5.0

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	1 and Under	1.25	1.5	2	2.5	3	3.5	4	5	6+

MAXIMUM SPACING (FEET)

Steel Pipe	7	8	9	10	11	12	13	14	16	17

3.5.4 Underground Piping

Installation of underground piping and fittings shall conform to NFPA 24. Joints shall be anchored in accordance with NFPA 24. Concrete thrust block shall be provided at elbow where pipe turns up towards floor, and the pipe riser shall be restrained with steel rods from the elbow to the flange above the floor. After installation in accordance with NFPA 24, rods and nuts shall be thoroughly cleaned and coated with asphalt or other corrosion-retard material approved by the Contracting Officer. Minimum depth of cover shall be 900 mm (3 feet).

3.5.5 Grooved Mechanical Joint

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.6 ELECTRICAL WORK

Electric motor and controls shall be in accordance with NFPA 20, NFPA 72 and NFPA 70, unless more stringent requirements are specified herein or are indicated on the drawings. Electrical wiring and associated equipment shall be provided in accordance with NFPA 20 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide wiring in rigid metal conduit or intermediate metal conduit, except electrical metallic tubing conduit may be provided in dry locations not enclosed in concrete or where not subject to mechanical damage.

3.7 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.8 FLUSHING

The fire pump suction and discharge piping shall be flushed at 120 percent of rated capacity of each pump. Where the pump installation consists of more than one pump, the flushing shall be the total quantity of water flowing when all pumps are discharging at 120 percent of their rated capacities. The new pumps may be used to attain the required flushing volume. No underground piping shall be flushed by using the fire pumps. Flushing operations shall continue until water is clear, but not less than

10 minutes. Submit a signed and dated flushing certificate before requesting field testing.

3.9 FIELD TESTS

Submit, at least 2 weeks before starting field tests, system diagrams that show the layout of equipment, piping, and storage units, and typed condensed sequence of operation, wiring and control diagrams, and operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed. Proposed diagrams, at least 2 weeks prior to start of related testing.

3.9.1 Hydrostatic Test

Piping shall be hydrostatically tested at 1551 kPa (225 psig) for a period of 2-hours, or at least 345 kPa (50 psi) in excess of the maximum pressure, when the maximum pressure in the system is in excess of 1207 kPa (175 psi) in accordance with NFPA 20.

3.9.2 Preliminary Tests

Submit proposed procedures for Preliminary Tests, at least 14 days prior to the proposed date and time to begin Preliminary Tests. The Fire Protection Specialist shall take all readings and measurements. The Manufacturer's Representative, a representative of the fire pump controller manufacturer, and a representative of the diesel engine manufacturer (when supplied) shall witness the complete operational testing of the fire pump and drivers. The fire pump controller manufacturer's representative and the diesel engine manufacturer's representative shall each be an experienced technician employed by the respective manufacturers and capable of demonstrating operation of all features of respective components including trouble alarms and operating features. Fire pumps, drivers and equipment shall be thoroughly inspected and tested to insure that the system is correct, complete, and ready for operation. Tests shall ensure that pumps are operating at rated capacity, pressure and speed. Tests shall include manual starting and running to ensure proper operation and to detect leakage or other abnormal conditions, flow testing, automatic start testing, testing of automatic settings, sequence of operation check, test of required accessories; test of pump alarms devices and supervisory signals, test of pump cooling, operational test of relief valves, and test of automatic power transfer, if provided. Pumps shall run without abnormal noise, vibration or heating. If any component or system was found to be defective, inoperative, or not in compliance with the contract requirements during the tests and inspection, the corrections shall be made and the entire preliminary test shall be repeated. Submit one hard copy and one digital copy (.pdf - text searchable) of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests. The Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Report shall be signed by the Fire Protection Specialist and the Manufacturer's Representative.

3.9.3 Army Final Acceptance Test

The Fire Protection Specialist shall take all readings and measurements.

The Manufacturer's Representative, the fire pump controller manufacturer's representative, and the diesel engine manufacturer's representative (when supplied) shall also witness for the final tests. Repair any damage caused by hose streams or other aspects of the test. Submit Acceptance Procedures and proposed date and time to begin Army Final Acceptance Test at least 14 days prior to the proposed start of the test. Submit one hard copy & one digital copy (.pdf - text searchable) of the completed Army Final Acceptance Test Reports, no later that 7 days after the completion of the tests. All items in the reports shall be signed by the Fire Protection Specialist and the Manufacturer's Representative. Test report shall be in booklet form (hard copy furnished in a properly labeled three ring binder) showing all field tests and measurements taken during the preliminary and final testing, and documentation that proves compliance with the specified performance criteria, upon completion of the installation and final testing of the installed system. Test report shall indicate the final position of the controls and pressure switches. The test reports shall include the description of the hydrostatic test conducted on the piping and flushing of the suction and discharge piping. A copy of the manufacturer's certified pump curve for each fire pump shall be included in the report. Notification shall include a copy of the Contractor's Material & Test Certificates. Include the following in the final acceptance test:

3.9.3.1 Flow Tests

Flow tests using the test header, hoses and play pipe nozzles shall be conducted. Flow tests shall be performed at churn (no flow), 75, 100, 125 and 150 percent capacity for each pump and at full capacity of the pump installation. Flow readings shall be taken from each nozzle by means of a calibrated pitot tube with gauge or other approved measuring equipment. Rpm, suction pressure and discharge pressure reading shall be taken as part of each flow test. Voltage and ampere readings shall taken on each phase as part of each flow test for electric-motor driven pumps.

3.9.3.2 Starting Tests

Pumps shall be tested for automatic starting and sequential starting. Setting of the pressure switches shall be tested when pumps are operated by pressure drop. Tests may be performed by operating the test connection on the pressure sensing lines. As a minimum, each pump shall be started automatically six times and manually six times, in accordance with NFPA 20. Tests of engine-driven pumps shall be divided equally between both set of batteries. Electric fire pumps shall be operated for a period of a least 5 minutes for each operation. Engine driven fire pumps shall not be required to run for 5 minutes at full speed between successive starts until the cumulative cranking time of successive starts reaches 45 seconds. Pressure settings that include automatic starting and stopping of the fire pump(s) shall be indicated on an etched plastic placard, attached to the corresponding pump controller.

3.9.3.3 Battery Changeover

Diesel driven fire pumps shall be tested for automatic battery changeover in event of failure of initial battery units.

3.9.3.4 Alarms

All pump alarms, both local and remote, shall be tested. Supervisory alarms for diesel drivers shall be electrically tested for low oil pressure, high engine jacket coolant temperature, shutdown from overspeed, battery failure and battery charger failure.

3.9.3.5 Miscellaneous

Valve tamper switches shall be tested. Pressure recorder operation relief valve settings, valve operations, operation and accuracy of meters and gauges, and other accessory devices shall be verified.

3.9.3.6 Alternate Power Source

On installations with an alternate source of power and an automatic transfer switch, loss of primary power shall be simulated and transfer shall occur while the pump is operating at peak load. Transfer from normal to emergency source and retransfer from emergency to normal source shall not cause opening of overcurrent devices in either line. At least half of the manual and automatic starting operations listed shall be performed with the fire pump connected to the alternate source.

3.9.3.7 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests shall be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.9.3.8 Test Documentation

The Manufacturer's Representative shall supply a copy of the manufacturer's certified curve for each fire pump at the time of the test. The Fire Protection Specialist shall record all test results and plot curve of each pump performance during the test. Complete pump acceptance test data of each fire pump shall be recorded. The pump acceptance test data shall be on forms that give the detail pump information such as that which is indicated in Figure A-11-2.6.3(f) of NFPA 20. All test data records shall be submitted in a three ring binder.

3.9.3.9 Certification of Installation

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the fire pump installation is in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

3.9.4 Test Equipment

Provide all equipment and instruments necessary to conduct a complete final test, including 65 mm (2.5 inch) diameter hoses, play pipe nozzles, pitot tube gauges, portable digital tachometer, voltage and ampere meters, and calibrated oil-filled water pressure gauges. Provide all necessary supports to safely secure hoses and nozzles during the test. The Government will furnish water for the tests.

3.9.5 As-Built Drawings

Submit As-Built Drawings, no later than 14 days after completion of the Final Tests. The Fire Pump Installation Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

3.10 DISINFECTION

After all system components are installed including pumps, piping, and other associated work, and all hydrostatic tests are successfully completed, thoroughly flush the pumps and all piping to be disinfected with potable water until there is no visible sign of dirt or other residue. and hydrostatic test are successfully completed, each portion of the piping specified in this Section system to be disinfected shall be thoroughly flushed with potable water until all entrained dirt and other foreign materials have been removed before introducing chlorinating material.

3.10.1 Chlorination

The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the sprinkler piping at a constant rate of 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or liquid chlorine injected into the system through a solution-fed chlorinator and booster pump shall be used. Chlorination application shall continue until the entire system if filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system shall be opened and closed several times to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system.

3.10.2 Flushing

The system shall then be flushed with clean water until the residual chlorine is reduced to less than one part per million. Samples of water in disinfected containers for bacterial examination will be taken from several system locations which are approved by the Contracting Officer.

3.10.3 Sample Testing

Samples shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA 10084. The testing method shall be either the multiple-tube fermentation technique or the membrane-filter technique. The disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.11 FIELD TRAINING

The Fire Protection Specialist and the Manufacturer's Representative shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit the proposed schedule for field training at least 14 days prior to the start of related training. Training shall be provided for a period of 8 hours of normal working time and shall start after the fire pump installation is functionally complete and after the Final Acceptance Test. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Data Package 3 shall be submitted for fire pumps and drivers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

-- End of Section --

SECTION 22 00 00

PLUMBING, GENERAL PURPOSE
11/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1010	(2002) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.1/CSA 4.1	(2009; Addenda A 2009; Addenda B 2011) Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less
ANSI Z21.10.3/CSA 4.3	(2013) Gas Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous
ANSI Z21.22/CSA 4.4	(1999; Addenda A 2000, Addenda B 2001; R 2014) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 146	(2011) Method of Testing and Rating Pool Heaters
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013; Errata 1-3 2013; Errata 4-6 2014; Errata 7 2015) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2008) Performance Requirements for Atmospheric Type Vacuum Breakers (ANSI approved 2009)
ASSE 1003	(2009) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI

	approved 2010)
ASSE 1010	(2004) Performance Requirements for Water Hammer Arresters (ANSI approved 2004)
ASSE 1011	(2004; Errata 2004) Performance Requirements for Hose Connection Vacuum Breakers (ANSI approved 2004)
ASSE 1012	(2009) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent - (ANSI approved 2009)
ASSE 1013	(2011) Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)
ASSE 1018	(2001) Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied (ANSI Approved 2002
ASSE 1019	(2011) Performance Requirements for Vacuum Breaker Wall Hydrants, Freeze Resistant, Automatic Draining Type (ANSI Approved 2004)
ASSE 1020	(2004; Errata 2004; Errata 2004) Performance Requirements for Pressure Vacuum Breaker Assembly (ANSI Approved 2004)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2005) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2010; Addenda 2011) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C606	(2011) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C652	(2011) Disinfection of Water-Storage Facilities
AWWA C700	(2009) Standard for Cold Water Meters - Displacement Type, Bronze Main Case
AWWA C701	(2012) Standard for Cold-Water Meters - Turbine Type for Customer Service

AWWA D100	(2011) Welded Steel Tanks for Water Storage

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2010) Specification for Brazing Procedure and Performance Qualification

ASME INTERNATIONAL (ASME)

ASME A112.1.2	(2012) Standard for Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
ASME A112.14.1	(2003; R 2012) Backwater Valves
ASME A112.19.1/CSA B45.2	(2013) Enameled Cast Iron and Enameled Steel Plumbing Fixtures
ASME A112.19.17	(2010) Manufactured Safety Vacuum Release Systems (SVRS) for Residential and Commercial Swimming Pool, Spa, Hot Tub, and Wading Pool Suction Systems
ASME A112.19.2/CSA B45.1	(2013) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals
ASME A112.19.3/CSA B45.4	(2008; R 2013) Stainless Steel Plumbing Fixtures
ASME A112.19.5	(2011) Trim for Water-Closet Bowls, Tanks and Urinals
ASME A112.19.8	(2007; Addenda A 2008; Addenda B 2009) Suction Fittings for Use in Swimming Pools, Wading Pools, Spas, And Hot Tubs
ASME A112.36.2M	(1991; R 2012) Cleanouts
ASME A112.6.1M	(1997; R 2012) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
ASME A112.6.3	(2001; R 2007) Standard for Floor and Trench Drains
ASME A112.6.4	(2003: R 2012) Roof, Deck and Balcony Drains
ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B16.12	(2009; R 2014) Cast Iron Threaded Drainage Fittings
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings

	Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.23	(2011) Cast Copper Alloy Solder Joint Drainage Fittings - DWV
ASME B16.24	(2011) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.29	(2012) Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.50	(2013) Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2010) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2012) Control and Safety Devices for Automatically Fired Boilers

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2014) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A515/A515M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A518/A518M	(1999; R 2012) Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A733	(2003; E 2009; R 2009) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A74	(2013a) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A888	(2013a) Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B111/B111M	(2011) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2013) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar

ASTM B306	(2013) Standard Specification for Copper Drainage Tube (DWV)
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B370	(2012) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B42	(2010) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B43	(2014) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B584	(2014) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B813	(2010) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2002; R 2010) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C1053	(2000; R 2010) Standard Specification for Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications
ASTM C564	(2014) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1004	(2013) Initial Tear Resistance of Plastic Film and Sheeting
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120

ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2235	(2004; R 2011) Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D2239	(2012) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2464	(2013) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2013a) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2661	(2011) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40, Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2672	(1996a; R 2009) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2683	(2010; E 2013; E 2014; E 2014) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2737	(2012a) Polyethylene (PE) Plastic Tubing
ASTM D2822/D2822M	(2005; E 2011; R 2011) Asphalt Roof Cement
ASTM D2846/D2846M	(2009; E 2011) Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems

ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D2996	(2001; E 2007; R 2007) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3035	(2014a) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3122	(1995; R 2009) Solvent Cements for Styrene-Rubber (SR) Plastic Pipe and Fittings
ASTM D3138	(2004; R 2011) Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2007; R 2013) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3261	(2012; E 2014) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D3311	(2011) Drain, Waste, and Vent (DWV) Plastic Fittings Patterns
ASTM D4101	(2014) Standard Specification for Polypropylene Injection and Extrusion Materials
ASTM D4551	(2012) Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials
ASTM F1290	(1998a; R 2011) Electrofusion Joining

	Polyolefin Pipe and Fittings
ASTM F1760	(2001; R 2011) Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content
ASTM F2387	(2004; R 2012) Standard Specification for Manufactured Safety Vacuum Release Systems (SVRS) for Swimming Pools, Spas, and Hot Tubs
ASTM F2389	(2010) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems
ASTM F409	(2012) Thermoplastic Accessible and Replaceable Plastic Tube and Tubular Fittings
ASTM F437	(2009) Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	(2009) Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	(2013) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441/F441M	(2013; E 2013) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F442/F442M	(2013; E 2013) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	(2010) Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F628	(2012; E 2013) Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe with a Cellular Core
ASTM F877	(2011a) Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems
ASTM F891	(2010) Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301	(2009) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(2011) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2010) Copper Tube Handbook

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO PS 117	(2005b) Press Type Or Plain End Rub Gasketed W/ Nail CU & CU Alloy Fittings 4 Install On CU Tubing

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2009) Accessible and Usable Buildings and Facilities
ICC IPC	(2012) International Plumbing Code

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

ANSI/ISEA Z358.1	(2009) American National Standard for Emergency Eyewash and Shower Equipment

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-44	(2010; Errata 2011) Steel Pipeline Flanges
MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2011) Butterfly Valves
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and

	Threaded Ends
MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(2006) Class 3000 Steel Pipe Unions Socket Welding and Threaded
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2014) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2011) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2015) National Fuel Gas Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2014) Plastics Piping System Components and Related Materials
NSF/ANSI 61	(2014) Drinking Water System Components - Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA Fire Man	(2010) Firestopping: Plastic Pipe in Fire Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI G 101	(2010) Testing and Rating Procedure for Hydro Mechanical Grease Interceptors with Appendix of Installation and Maintenance
PDI WH 201	(2010) Water Hammer Arresters Standard

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508	(2009) Hose Clamp Specifications

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SM 9223	(2004) Enzyme Substrate Coliform Test
Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)
PL 93-523	(1974; A 1999) Safe Drinking Water Act

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC	Leadership in Energy and Environmental Design(tm) New Construction Rating System

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 430	Energy Conservation Program for Consumer Products
21 CFR 175	Indirect Food Additives: Adhesives and Components of Coatings
40 CFR 141.80	National Primary Drinking Water Regulations; Control of Lead and Copper; General Requirements
PL 109-58	Energy Policy Act of 2005 (EPAct05)

UNDERWRITERS LABORATORIES (UL)

UL 174	(2004; Reprint Sep 2012) Household Electric Storage Tank Water Heaters
UL 430	(2009; Reprint Oct 2013) Standard for Waste Disposers
UL 499	(2014) Electric Heating Appliances
UL 732	(1995; Reprint Oct 2013) Oil-Fired Storage Tank Water Heaters

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1532	(2002) Screwed Drainage Fittings

KS B 1534	(2009) Fittings for Sanitary Wares
KS B 1565	(2009) Floor Drain
KS B 2301	(2009) Bronze Gate, Globe, Angle and Check Valves
KS B 2308	(2012) Ball Valve
KS B 2333	(2012) Butterfly Valves for Water Works
KS B 2350	(2009) Gray Cast Iron Valves
KS B 2356	(2003) Malleable Iron 10 K Screwed Valves
KS B 2361	(2007) Cast Steel Flanged Valves
KS B 5215	(1983) Mercury Filled Thermometers
KS B 5305	(2008) Bourdon Tube Pressure Gauges
KS B 6153	(2006) Pressure Reducing Valves For Water Works
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 4301	(2006) Grey Iron Castings
KS D 4307	(2009) Cast-Iron Soil Pipes and Fittings
KS D 5201	(2009) Copper and Copper Alloy Sheets, Plates and Strips
KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes
KS D 5578	(2009) Pipe Fittings of Copper and Copper Alloys
KS D 6704	(2001) Soft Solder
KS D 8307	(2001) Coal-tar Enamel Protective Coatings for Steel Water Pipe
KS F 4806	(2007) Bathtubs
KS L 1551	(2009) Sanitary Wares
KS M 1103	(2008) Liquid Chlorine
KS M 2201	(2007) Straight Asphalt
KS M 3401	(2009) Unplasticized Polyvinyl Chloride Pipes for Water Works
KS M 3402	(2009) Rigid Polyvinyl Chloride Pipe Fittings for Water Works Service

KS M 3404	(2009) Unplasticized Polyvinyl Chloride Pipes for General Service
KS M 3410	(2009) Unplasticized Polyvinyl Chloride Pipes Fittings for Drain
KS M 3520	(2011) Unsintered Polytetrafluoroethylene Tapes for Tread Sealing
KS M 6613	(2007) Rubber Goods for Water Works Service

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Fixtures; (LEED NC)

List of installed fixtures with manufacturer, model, and flow rate.

Flush valve water closets

Flush valve urinals

Flush tank water closets

Wall hung lavatories

Countertop lavatories

Kitchen sinks

Service sinks

Drinking-water coolers; G

Bathtubs, Porcelain

Bathtubs, Cast Iron

Water heaters; G

Pumps; G

Backflow prevention assemblies; G

Shower Faucets; G

Swimming Pool and Spa Suction Fittings; G

Pool Water Pump safety vacuum release system; G

Welding

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Vibration-Absorbing Features; G

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Cast Iron Soil Pipe and Fittings

SD-06 Test Reports

Tests, Flushing and Disinfection

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies.

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

Plumbing System

SD-07 Certificates

Materials and Equipment

Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code.

Bolts

Written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G.

1.3 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.1 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.2 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.3 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.3.4 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX or KS (Korean Industrial Standards). Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL.

1.5.2 Cathodic Protection and Pipe Joint Bonding

Cathodic protection and pipe joint bonding systems shall be in accordance with Section 26 42 14.00 10 CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE) and Section 26 42 17.00 10 CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT).

1.6 REGULATORY REQUIREMENTS

Unless otherwise required herein, plumbing work shall be in accordance with ICC IPC. Energy consuming products and systems shall be in accordance with PL 109-58 and ASHRAE 90.1 - SI ASHRAE 90.1 - IP

1.7 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.8 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.9 Detail Drawings

Contractor shall prepare and submit detail drawings consisting of schedules, performance charts, instructions, diagrams, and other information to illustrate the requirements and operations of systems that are not covered by the Plumbing Code. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale. Detail drawings consisting of schedules, performance charts, instructions, diagrams, and other information to illustrate the requirements and operations of systems that are not covered by the Plumbing Code. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale.

1.10 ACCESSIBILITY OF EQUIPMENT

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 Materials

Materials for various services shall be in accordance with TABLES I and II. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement used for potable hot and cold water service shall bear the NSF seal "NSF-PW." Polypropylene pipe and fittings shall conform to dimensional requirements of Schedule 40, Iron Pipe size and shall comply with

NSF/ANSI 14, NSF/ANSI 61 and ASTM F2389. Polypropylene piping that will be exposed to UV light shall be provided with a Factory applied UV resistant coating. Pipe threads (except dry seal) shall conform to ASME B1.20.1. Grooved pipe couplings and fittings shall be from the same manufacturer. Material or equipment containing lead shall not be used in any potable water system. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF/ANSI 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9. Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Plastic pipe shall not be installed in air plenums. Plastic pipe shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

2.1.1 Pipe Joint Materials

Grooved pipe and hubless cast-iron soil pipe shall not be used underground. Solder containing lead shall not be used with copper pipe. Cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Institute. Joints and gasket materials shall conform to the following:

a. Coupling for Cast-Iron Pipe: for hub and spigot type ASTM A74, AWWA C606, KS D 4307. For hubless type: CISPI 310

b. Coupling for Steel Pipe: AWWA C606.

c. Couplings for Grooved Pipe: Ductile Iron ASTM A536 (Grade 65-45-12) or KS D 4301, Malleable Iron ASTM A47/A47M, Grade 32510. Copper ASTM A536 or KS D 4307.

d. Flange Gaskets: Gaskets shall be made of non-asbestos material in accordance with ASME B16.21. Gaskets shall be flat, 1.6 mm (1/16 inch) thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.

e. Brazing Material: Brazing material shall conform to AWS A5.8/A5.8M, BCuP-5.

f. Brazing Flux: Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides; and contain fluorides.

g. Solder Material: Solder metal shall conform to ASTM B32 or KS D 6704.

h. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B813, Standard Test 1.

i. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe. ASTM D3308 or KS M 3520.

j. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): ASTM C564.

k. Rubber Gaskets for Grooved Pipe: ASTM D2000, maximum temperature 110 degrees C (230 degrees F).

l. Flexible Elastomeric Seals: ASTM D3139, ASTM D3212, ASTM F477, or KS M 6613.

m. Bolts and Nuts for Grooved Pipe Couplings: Heat-treated carbon steel, ASTM A183.

n. Solvent Cement for Transition Joints between ABS and PVC Nonpressure Piping Components: ASTM D3138.

o. Plastic Solvent Cement for ABS Plastic Pipe: ASTM D2235.

p. Plastic Solvent Cement for PVC Plastic Pipe: ASTM D2564 and ASTM D2855.

q. Plastic Solvent Cement for CPVC Plastic Pipe: ASTM F493.

r. Flanged fittings including flanges, bolts, nuts, bolt patterns, etc., shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M.

s. Plastic Solvent Cement for Styrene Rubber Plastic Pipe: ASTM D3122.

t. Press fittings for Copper Pipe and Tube: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for copper press fittings shall be EPDM, FKM or HNBR. Sealing elements shall be factory installed or an alternative supplied fitting manufacturer. Sealing element shall be selected based on manufacturer's approved application guidelines.

u. Copper tubing shall conform to ASTM B88M (ASTM B88), Type K, L, or M or KS D 5301.

v. Heat-fusion joints for polypropylene piping: ASTM F2389 or KS M 3402.

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

a. Water Hammer Arrester: PDI WH 201. Water hammer arrester shall be diaphragm or piston type.

b. Copper, Sheet and Strip for Building Construction: ASTM B370 or KS D 5201.

c. Asphalt Roof Cement: ASTM D2822/D2822M or KS M 2201.

d. Hose Clamps: SAE J1508.

e. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M or KS B 1534.

f. Metallic Cleanouts: ASME A112.36.2M or KS B 1565.

g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile non-asphaltic and contain germicide and provide watertight, gastight, odor proof and vermin proof properties.

h. Coal-Tar Protective Coatings and Linings for Steel Water Pipelines: AWWA C203 or KS D 8307.

i. Hypochlorites: AWWA B300.

j. Liquid Chlorine: AWWA B301 or KS M 1103.

k. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.100 or KS B 5305.

l. Thermometers: ASTM E1 or KS B 5215. Mercury shall not be used in thermometers.

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.3 VALVES

Valves shall be provided on supplies to equipment and fixtures. Valves 65 mm (2-1/2 inches) and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 80 mm (3 inches) and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Grooved end valves may be provided if the manufacturer certifies that the valves meet the performance requirements of applicable MSS standard. Valves shall conform to the following standards:

Description	Standard
Butterfly Valves	MSS SP-67 or KS B 2333
Cast-Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70, KS B 2350, KS B 2356, or KS B 2361
Cast-Iron Swing Check Valves, Flanged and Threaded Ends	MSS SP-71, KS B 2350 , KS B 2356, or KS B 2361
Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72 or KS B 2308

Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110 or KS B 2308
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80 or KS B 2301
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Cast-Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85, KS B 2350 , KS B 2356, or KS B 2361
Backwater Valves	ASME A112.14.1
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4
Water Pressure Reducing Valves	ASSE 1003 or KS B 6153
Water Heater Drain Valves	ASME BPVC SEC IV, Part HLW-810: Requirements for Potable-Water Heaters Bottom Drain Valve
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22/CSA 4.4
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code No., Part CW, Article 5

2.3.1 Backwater Valves

Backwater valves shall be either separate from the floor drain or a combination floor drain, P-trap, and backwater valve, as shown. Valves shall have cast-iron bodies with cleanouts large enough to permit removal of interior parts. Valves shall be of the flap type, hinged or pivoted, with revolving disks. Hinge pivots, disks, and seats shall be nonferrous metal. Disks shall be slightly open in a no-flow no-backwater condition. Cleanouts shall extend to finished floor and be fitted with threaded countersunk plugs.

2.3.2 Wall Faucets

Wall faucets with vacuum-breaker backflow preventer shall be brass with 20 mm (3/4 inch) male inlet threads, hexagon shoulder, and 20 mm (3/4 inch) hose connection. Faucet handle shall be securely attached to stem.

2.3.3 Wall Hydrants (Frost Proof)

ASSE 1019 with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 20 mm (3/4 inch) exposed hose thread on spout and 20 mm (3/4 inch) male pipe thread on inlet.

2.3.4 Lawn Faucets

Lawn faucets shall be brass, with either straight or angle bodies, and shall be of the compression type. Body flange shall be provided with internal pipe thread to suit 20 mm (3/4 inch) pipe. Body shall be suitable for wrench grip. Faucet spout shall have 20 mm (3/4 inch) exposed hose threads. Faucet handle shall be securely attached to stem.

2.3.5 Yard Hydrants

Yard box or post hydrants shall have valve housings located below frost lines. Water from the casing shall be drained after valve is shut off. Hydrant shall be bronze with cast-iron box or casing guard. "T" handle key shall be provided.

2.3.6 Relief Valves

Water heaters and hot water storage tanks shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22/CSA 4.4. Relief valves for systems where the maximum rate of heat input is less than 59 kW (200,000 Btuh) shall have 20 mm3/4 inch minimum inlets, and 20 mm (3/4 inch) outlets. Relief valves for systems where the maximum rate of heat input is greater than 59 kW (200,000 Btuh) shall have 25 mm (1 inch) minimum inlets, and 25 mm (1 inch) outlets. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.7 Thermostatic Mixing Valves

Provide thermostatic mixing valve for lavatory faucets. Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 2 degrees C (5 degrees F) of any setting.

2.4 FIXTURES

Fixtures shall be water conservation type, in accordance with ICC IPC. Fixtures for use by the physically handicapped shall be in accordance with ICC A117.1. ASME A112.19.3/CSA B45.4 302 stainless steel or Vitreous China, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush and/or flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees and shoes of bathtub waste drains may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years or shall be copper alloy with all visible surfaces chrome plated. Plastic in contact with hot water shall be suitable for 82 degrees C (180 degrees F) water temperature.

2.4.1 Lavatories

Enameled cast-iron lavatories shall be provided with two cast-iron or steel brackets secured to the underside of the apron and drilled for bolting to the wall in a manner similar to the hanger plate. Exposed brackets shall be porcelain enameled. Vitreous china lavatories shall be provided with two integral molded lugs on the back-underside of the fixture and drilled for bolting to the wall in a manner similar to the hanger plate.

2.4.2 Automatic Controls

Flushing and faucet systems shall consist of solenoid-activated valves with light beam sensors. Flush valve for water closet shall include an override pushbutton. Flushing devices shall be provided as described in paragraph FIXTURES AND FIXTURE TRIMMINGS.

2.4.3 Flush Valve Water Closets

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china, or ASME A112.19.3/CSA B45.4 302 Stainless Steel, siphon jet, elongated bowl, floor-mounted, floor outlet or wall mounted, wall outlet. Top of toilet seat height above floor shall be 356 to 381 mm (14 to 15 inches), except 432 to 483 mm (17 to 19 inches) for wheelchair water closets. Provide wax bowl ring including plastic sleeve. Provide white solid plastic elongated open-front seat or closed-front seat with cover.

Water flushing volume of the water closet and flush valve combination shall not exceed 6.1 or 3.8 liters(1.6 or 1.0 gallons) per flush. Provide a dual-flush water closet and flush valve combination that will also provide a second flushing water volume not to exceed 4.1 liters (1.1 gallons) per flush.

Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be non-hold-open type. Mount flush valves not less than 279 mm (11 inches) above the fixture. Mounted height of flush valve shall not interfere with the hand rail in ADA stalls. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid. Provide piston type, oil operated, flush valve and wall support for salt water service.

2.4.4 Flush Valve Urinals

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china, or ASME A112.19.3/CSA B45.4 302 stainless steel, wall-mounted, wall outlet, siphon jet, integral trap, and extended side shields. Provide urinal with the rim 610 mm (24 inches) above the floor. Water flushing volume of the urinal and flush valve combination shall not exceed 1.9, 3.8 or 0.5 liters(0.5, 1.0 or 0.125 gallons) per flush. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports. Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be non-hold-open type. Mount flush valves not less than 279 mm (11 inches) above the fixture. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid. Provide piston type, oil operated, flush valve and wall support for salt water service.

2.4.5 Wheelchair Flush Valve Type Urinals

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china, or ASME A112.19.3/CSA B45.4 302 stainless steel, wall-mounted, wall outlet, blowout action, integral trap, elongated projecting bowl, 508 mm (20 inches) long from wall to front of flare, and ASME A112.19.5 trim. Provide large diaphragm (not less than 66 mm (2.625 inches) upper chamber inside diameter at the point where the diaphragm is sealed between the upper and lower chambers), non-hold-open flush valve of chrome plated cast brass conforming to ASTM B584, including vacuum breaker and angle (control-stop) valve with back check. The water flushing volume of the flush valve and urinal combination shall not exceed 1.9, 3.8 or 0.5 liters (0.5, 1.0 or 0.125 gallon) per flush. Furnish urinal manufacturer's certification of conformance. Provide ASME A112.6.1M concealed chair carriers. Mount urinal with front rim a maximum of 432 mm (17 inches) above floor and flush valve handle a maximum of 1118 mm (44 inches) above floor for use by handicapped on wheelchair. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid.

2.4.6 Flush Tank Water Closets

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china, or

ASME A112.19.3/CSA B45.4 302 stainless steel, siphon jet, round bowl, pressure assisted, floor-mounted, floor outlet. Top of toilet seat height above floor shall be 356 to 381 mm (14 to 15 inches), except 432 to 483 mm (17 to 19 inches) for wheelchair water closets. Nonfloat swing type flush tank valves are not acceptable. Gravity tank type water closets are not permitted. Provide wax bowl ring including plastic sleeve. Water flushing volume of the water closet shall not exceed 4.85 or 3.8 liters (1.28 or 1.0 gallons) per flush. Provide a dual-flush toilet with a second flushing option that shall not exceed 4.1 liters (1.1 gallons) per flush. Provide white solid plastic round closed-front seat with cover. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid.

2.4.7 Non-Flushing Toilets

Provide composting toilets in accordance with manufacturer's recommendations. Provide vacuum toilet systems in accordance with manufacturer's recommendations.

2.4.8 Wall Hung Lavatories

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china, or ASME A112.19.3/CSA B45.4 302 stainless steel, straight back type, minimum dimensions of 483 mm (19 inches), wide by 432 mm (17 inches) front to rear, with supply openings for use with top mounted center set faucets, and openings for concealed arm carrier installation. Provide aerator with faucet. Water flow rate shall not exceed 30, 60 or 90 mL per second (0.5, 1.0 or 1.5 gpm) when measured at a flowing water pressure of 414 kPa (60 psi). Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports and concealed arms for the lavatory. Mount lavatory with the front rim 864 mm (34 inches) above floor and with 737 mm (29 inches) minimum clearance from bottom of the front rim to floor. Provide top mounted washerless center set lavatory faucets. Provide top-mounted solenoid-activated lavatory faucets including electrical-operated light-beam-sensor to energize the solenoid.

2.4.9 Countertop Lavatories

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china or ASME A112.19.3/CSA B45.4 302 stainless steel, self-rimming, minimum dimensions of 483 mm (19 inches) wide by 432 mm (17 inches) front to rear, with supply openings for use with top mounted center set faucets. Furnish template and mounting kit by lavatory manufacturer. Provide aerator with faucet. Water flow rate shall not exceed 30, 60 or 90 mL per second (0.5, 1.0 or 1.5 gpm) when measured at a flowing water pressure of 414 kPa (60 psi). Mount counter with the top surface 864 mm (34 inches) above floor and with 737 mm (29 inches) minimum clearance from bottom of the counter face to floor. Provide top mounted washerless center set lavatory faucets. Provide top-mounted solenoid-activated lavatory faucets including electrical-operated light-beam-sensor to energize the solenoid.

2.4.10 Kitchen Sinks

ASME A112.19.3/CSA B45.4, 20 gage stainless steel with integral mounting rim for flush installation, minimum dimensions of 838 mm (33 inches) wide by 533 mm21 inches front to rear, two compartments, with undersides fully sound deadened, with supply openings for use with top mounted washerless sink faucets with hose spray, and with 89 mm (3.5 inch) drain outlet. Provide aerator with faucet. Water flow rate shall not exceed 30, 60 or

90 mL per second (0.5, 1.0 or 1.5 gpm) when measured at a flowing water pressure of 414 kPa (60 psi). Provide stainless steel drain outlets and stainless steel cup strainers. Provide separate 38 mm (1.5 inch) P-trap and drain piping to vertical vent piping from each compartment. Provide top mounted washerless sink faucets with hose spray. Provide UL 430 waste disposer in right compartment. Provide pedal valve for foot-operated flow control. Provide secondary kitchen sink that drains to gray water system. Provide sink with disposal chute to compost bucket under sink.

2.4.11 Service Sinks

ASME A112.19.2/CSA B45.1 or KS L 1551, white vitreous china or ASME A112.19.3/CSA B45.4 302 stainless steel with integral back and wall hanger supports, minimum dimensions of 559 mm (22 inches) wide by 508 mm (20 inches) front to rear, with two supply openings in 254 mm (10 inch) high back. Provide floor supported wall outlet cast iron P-trap and stainless steel rim guards as recommended by service sink manufacturer. Provide back mounted washerless service sink faucets with vacuum breaker and 19 mm (0.75 inch) external hose threads.

2.4.12 Drinking-Water Coolers

AHRI 1010 with more than a single thickness of metal between the potable water and the refrigerant in the heat exchanger, wall-hung, bubbler style, air-cooled condensing unit, 5 ml per second (4.75 gph) minimum capacity, stainless steel splash receptor and basin, and stainless steel cabinet. Bubblers shall be controlled by push levers or push bars, front mounted or side mounted near the front edge of the cabinet. Bubbler spouts shall be mounted at maximum of 914 mm (36 inches) above floor and at front of unit basin. Spouts shall direct water flow at least 102 mm (4 inches) above unit basin and trajectory parallel or nearly parallel to the front of unit. Provide ASME A112.6.1M concealed steel pipe chair carriers.

2.4.13 Wheelchair Drinking Water cooler

AHRI 1010, wall-mounted bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 5 mL per second (4.75 gph) minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 686 mm (27 inch) minimum knee clearance from front bottom of unit to floor and 914 mm (36 inch) maximum spout height above floor. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet.

2.4.14 Precast Terrazzo Shower Floors

Terrazzo shall be made of marble chips cast in white portland cement to produce 25 mPa (3000 psi) minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

2.4.15 Precast Terrazzo Mop Sinks

Terrazzo shall be made of marble chips cast in white portland cement to produce 25 mPa (3000 psi) minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

2.4.16 Bathtubs, Cast Iron

ASME A112.19.1/CSA B45.2 or KS F 4806, white enameled cast iron, recessed type, minimum dimensions of 1524 mm (60 inches) wide by 762 mm (30 inches) front to rear by 406 mm (16 inches) high with drain outlet for above-the-floor drain installation. Provide left or right drain outlet bathtub as indicated.

2.4.17 Bathtubs, Porcelain

ASME A112.19.1/CSA B45.2 or KS F 4806, white porcelain bonded to enameling grade metal, bonded to a structural composite, recessed type, minimum dimensions of 1524 mm (60 inches) wide by 762 mm (30 inches) front to rear by 406 mm (16 inches) high with drain outlet for above-the-floor drain installation. Provide left or right drain outlet bathtub as indicated.

2.4.18 Emergency Eyewash and Shower

ANSI/ISEA Z358.1, floor supported free standing unit. Provide deluge shower head, stay-open ball valve operated by pull rod and ring or triangular handle. Provide eyewash and stay-open ball valve operated by foot treadle or push handle.

2.4.19 Emergency Eye and Face Wash

ANSI/ISEA Z358.1, wall-mounted self-cleaning, non-clogging eye and face wash with quick opening, full-flow valves, stainless steel eye and face wash receptor. Unit shall deliver 0.19 L/s (3 gpm) of aerated water at 207 kPa (gage) (30 psig) flow pressure, with eye and face wash nozzles 838 to 1143 mm (33 to 45 inches) above finished floor. Provide copper alloy control valves. Provide an air-gap with the lowest potable eye and face wash water outlet located above the overflow rim by not less than the International Plumbing Code minimum. Provide a pressure-compensated tempering valve, with leaving water temperature setpoint adjustable throughout the range 15.5 to 35 degrees C (60 to 95 degrees F). Provide packaged, UL listed, alarm system; including an amber strobe lamp, horn with externally adjustable loudness and horn silencing switch, mounting hardware, and waterflow service within NEMA Type 3 or 4 enclosures and for explosion proof service within NEMA Type 7 or 9 enclosures.

2.5 BACKFLOW PREVENTERS

The backflow prevention devices must be listed by the Foundation for Cross-Connection Control & Hydraulic Research, or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention devices and assemblies.

Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be meet the above requirements.

Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 Floor and Shower Drains

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to ASME A112.6.3. Provide drain with trap primer connection, trap primer, and connection piping. Primer shall meet ASSE 1018.

2.6.1.1 Metallic Shower Pan Drains

Where metallic shower pan membrane is installed, polyethylene drain with corrosion-resistant screws securing the clamping device shall be provided. Polyethylene drains shall have fittings to adapt drain to waste piping. Polyethylene for floor drains shall conform to ASTM D1248. Drains shall have separate cast-iron "P" trap, circular body, seepage pan, and strainer, unless otherwise indicated.

2.6.1.2 Drains and Backwater Valves

Drains and backwater valves installed in connection with waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.

2.6.2 Bathtub and Shower Faucets and Drain Fittings

Provide single control pressure equalizing bathtub and shower faucets with body mounted from behind the wall with threaded connections. Provide ball joint self-cleaning shower heads. Provide shower heads which deliver a maximum of 0.139 l/s at 551 kPa (2.2 GPM at 80 PSI) per Energy Star requirements. Provide tubing mounted from behind the wall between bathtub faucets and shower heads and bathtub diverter spouts. Provide separate globe valves or angle valves with union connections in each supply to faucet. Provide trip-lever pop-up drain fittings for above-the-floor drain installations. The top of drain pop-ups, drain outlets, tub overflow outlet, and; control handle for pop-up drain shall be chromium-plated or polished stainless steel. Linkage between drain pop-up and pop-up control handle at bathtub overflow outlet shall be copper alloy or stainless steel. Provide 40 mm (1.5 inch) copper alloy adjustable tubing with slip nuts and gaskets between bathtub overflow and drain outlet; chromium-plated finish is not required. Provide bathtub and shower valve with ball type control handle.

2.6.3 Area Drains

Area drains shall be plain pattern with polished stainless steel perforated or slotted grate and bottom outlet. The drain shall be circular or square with a 300 mm (12 inch) nominal overall width or diameter and 250 mm (10 inch)nominal overall depth. Drains shall be cast iron with manufacturer's standard coating. Grate shall be easily lifted out for cleaning. Outlet shall be suitable for inside caulked connection to drain pipe. Drains shall conform to ASME A112.6.3.

2.6.4 Floor Sinks

Floor sinks shall be circular or square, with 300 mm (12 inch) nominal overall width or diameter and 250 mm (10 inch) nominal overall depth. Floor sink shall have an acid-resistant enamel interior finish with cast-iron body, aluminum sediment bucket, and perforated grate of cast iron in industrial areas and stainless steel in finished areas. The outlet pipe size shall be as indicated or of the same size as the connecting pipe.

2.6.5 Boiler Room Drains

Boiler room drains shall have combined drain and trap, hinged grate, removable bucket, and threaded brass cleanout with brass backwater valve. The removable galvanized cast-iron sediment bucket shall have rounded corners to eliminate fouling and shall be equipped with hand grips. Drain shall have a minimum water seal of 100 mm (4 inches). The grate area shall be not less than 0.065 square meters (100 square inches).

2.6.6 Pit Drains

Pit drains shall consist of a body, integral seepage pan, and nontilting perforated or slotted grate. Drains shall be of double drainage pattern suitable for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drain pipe. Membrane or flashing clamping device shall be provided when required. Drains shall be cast iron with manufacturer's standard coating. Drains shall be circular and provided with bottom outlet suitable for inside caulked connection, unless otherwise indicated. Drains shall be provided with separate cast-iron "P" traps, unless otherwise indicated.

2.6.7 Sight Drains

Sight drains shall consist of body, integral seepage pan, and adjustable strainer with perforated or slotted grate and funnel extension. The strainer shall have a threaded collar to permit adjustment to floor thickness. Drains shall be of double drainage pattern suitable for embedding in the floor construction. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane shall be provided for other than concrete construction. Drains shall have a galvanized heavy cast-iron body and seepage pan and chromium-plated bronze, nickel-bronze, or nickel-brass strainer and funnel combination. Drains shall be provided with threaded connection and with a separate cast-iron "P" trap, unless otherwise indicated. Drains shall be circular, unless otherwise indicated. The funnel shall be securely mounted over an opening in the center of the strainer. Minimum dimensions shall be as follows:

Area of strainer and collar:	0.023 square meters (36 square inches)
Height of funnel:	95 mm (3-3/4 inches)
Diameter of lower portion:	50 mm (2 inches) of funnel

Diameter of upper portion: 100 mm (4 inches) of funnel

2.6.8 Roof Drains and Expansion Joints

Roof drains shall conform to ASME A112.6.4, with dome and integral flange, and shall have a device for making a watertight connection between roofing and flashing. The whole assembly shall be galvanized heavy pattern cast iron. For aggregate surface roofing, the drain shall be provided with a gravel stop. On roofs other than concrete construction, roof drains shall be complete with under deck clamp, sump receiver, and an extension for the insulation thickness where applicable. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane shall be provided when required to suit the building construction. Strainer openings shall have a combined area equal to twice that of the drain outlet. The outlet shall be equipped to make a proper connection to threaded pipe of the same size as the downspout. An expansion joint of proper size to receive the conductor pipe shall be provided. The expansion joint shall consist of a heavy cast-iron housing, brass or bronze sleeve, brass or bronze fastening bolts and nuts, and gaskets or packing. The sleeve shall have a nominal thickness of not less than 3.416 mm (0.134 inch). Gaskets and packing shall be close-cell neoprene, O-ring packing shall be close-cell neoprene of 70 durometer. Packing shall be held in place by a packing gland secured with bolts.

2.6.9 Swimming Pool and Spa Suction Fittings

Pool water suction fittings in swimming pools and spas shall comply with ASME A112.19.8 and addenda A112.19.8a. The compliance of the fitting shall include of the associated drain cover, sump, and hardware. The fitting shall be permanently marked to indicate compliance with the ASME standard, or permanently marked with the symbol "VGB 2008".

2.7 SHOWER PAN

Shower pan may be copper, or nonmetallic material.

2.7.1 Sheet Copper

Sheet copper shall be 4.9 kg per square meter (16 ounce) weight.

2.7.2 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be 1.016 mm (0.040 inch) minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with ASTM D4551.

2.7.3 Nonplasticized Polyvinyl Chloride (PVC) Shower Pan Material

Material shall consist of a plastic waterproofing membrane in sheet form. The material shall be 1.016 mm (0.040 inch) minimum thickness of nonplasticized PVC and shall have the following minimum properties:

a. or ASTM D638:

Ultimate Tensile Strength:	1.79 MPa (2600 psi)
Ultimate Elongation:	398 percent
100 Percent Modulus:	3.07 MPa (445 psi)

b. ASTM D1004:

Tear Strength:	53 kilonewtons per meter (300 pounds per inch)

c. ASTM E96/E96M:

Permeance:	0.46 ng per Pa per second per sq meter (0.008 perms)

d. Other Properties:

Specific Gravity:	1.29
PVC Solvent:	Weldable
Cold Crack:	minus 47 degrees C (53 degrees F)
Dimensional stability	100 degrees C (212 degrees F minus 2.5 percent)
Hardness, Shore A:	89

2.8 TRAPS

Unless otherwise specified, traps shall be plastic per ASTM F409 or copper-alloy adjustable tube type with slip joint inlet and swivel. Traps shall be without a cleanout. Provide traps with removable access panels for easy clean-out at sinks and lavatories. Tubes shall be copper alloy with walls not less than 0.813 mm (0.032 inch) thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 50 mm (2 inches). The interior diameter shall be not more than 3.2 mm (1/8 inch) over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 INTERCEPTORS

2.9.1 Grease Interceptor

Grease interceptor of the size indicated shall be of reinforced concrete, precast concrete construction, or equivalent capacity commercially available steel grease interceptor with removable three-section, 9.5 mm (3/8 inch) checker-plate cover, and shall be installed outside the building. Steel grease interceptor shall be installed in a concrete pit and shall be epoxy-coated to resist corrosion as recommended by the manufacturer. Interceptors shall be tested and rated in accordance with PDI G 101. Concrete shall have 21 MPa (3,000 psi) minimum compressive strength at 28 days. Provide flow control fitting.

2.9.2 Oil Interceptor

Cast iron or welded steel, coated inside and outside with white acid resistant epoxy, with internal air relief bypass, bronze cleanout plug, double wall trap seal, removable combination pressure equalizing and flow diffusing baffle and sediment bucket, horizontal baffle, adjustable oil draw-off and vent connections on either side, gas and watertight gasketed nonskid cover, and flow control fitting.

2.9.3 Sand Interceptors

Sand interceptor of the size indicated shall be of reinforced concrete, precast concrete construction, or equivalent capacity commercially available steel sand interceptor with manufacturer's standard checker-plate cover, and shall be installed outside the building, top flush with the floor, or floor mounted. Steel sand interceptor shall be installed in accordance with manufacturer's recommendations and shall be coated to resist corrosion as recommended by the manufacturer. Concrete shall have 21 MPa (3,000 psi) minimum compressive strength at 28 days.

2.10 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 32 to 71 degrees C (90 to 160 degrees F). Each gas-fired water heater and booster water heater shall have controls with an adjustable range that includes 49 to 82 degrees C (120 to 180 degrees F). Hot water systems utilizing recirculation systems shall be tied into building off-hour controls. The thermal efficiencies and standby heat losses shall conform to TABLE III for each type of water heater specified. The only exception is that storage water heaters and hot water storage tanks having more than 2000 liters (500 gallons) storage capacity need not meet the standard loss requirement if the tank surface area is insulated to R-12.5 and if a standing light is not used. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 93 degrees C (200 degrees F) water temperature and 1034 kPa (150 psi) working pressure. The expansion tank size and acceptance volume shall be as indicated.

2.10.1 Automatic Storage Type

Heaters shall be complete with control system, temperature gauge, and pressure gauge, and shall have ASME rated combination pressure and temperature relief valve.

2.10.1.1 Oil-Fired Type

Oil-fired type water heaters shall conform to UL 732.

2.10.1.2 Gas-Fired Type

Gas-fired water heaters shall conform to ANSI Z21.10.1/CSA 4.1 when input is 22 KW (75,000 BTU) per hour or less or ANSI Z21.10.3/CSA 4.3 for heaters with input greater than 22 KW (75,000 BTU) per hour.

2.10.1.3 Electric Type

Electric type water heaters shall conform to UL 174 with dual heating elements. Each element shall be 4.5 KW. The elements shall be wired so that only one element can operate at a time.

2.10.1.4 Indirect Heater Type

Steam and high temperature hot water (HTHW) heaters with storage system shall be the assembled product of one manufacturer, and be ASME tested and "U" stamped to code requirements under ASME BPVC SEC VIII D1. The storage tank shall be as specified in paragraph HOT-WATER STORAGE TANKS. The heat exchanger shall be double wall or single wall type that separates the potable water from the heat transfer medium with a space vented to the atmosphere in accordance with ICC IPC.

a. HTHW Energy Source: The heater element shall have a working pressure of 2758 kPa (400 psig) with water at a temperature of 204 degrees C (400 degrees F). The heating surface shall be based on 0.093 square meter (1 square foot) of heating surface to heat 76 L (20 gallons) or more of water in 1 hour from 4 to 82 degrees C (40 to 180 degrees F) using hot water at a temperature of 178 degrees C (350 degrees F). Carbon steel heads shall be used. Tubing shall conform to ASTM B111/B111M, Copper Alloy No. 706 (90-10 copper-nickel). Heating elements shall withstand an internal hydrostatic pressure of 4137 kPa (600 psig) for not less than 15 seconds without leaking or any evidence of damage.

b. Steam Energy Source: The heater element shall have a working pressure of 1034 kPa per square meter (150 pounds per square inch) gauge (psig) with steam at a temperature of 185 degrees C (365 degrees F). The heating surface shall be based on 0.093 square meter (1 square foot) of heating surface to heat 76 L (20 gallons) or more of water in 1 hour from 4 to 82 degrees C (40 to 180 degrees F) using steam at atmospheric pressure. Cast iron or bronze heads shall be used. Tubing shall be light-drawn copper tubing conforming toASTM B75/B75M. Heating elements shall withstand an internal hydrostatic pressure of 1551 kPa (225 psig) for not less than 15 seconds without leaking or any evidence of damage.

2.10.2 Instantaneous Water Heater

Heater shall be crossflow design with service water in the coil and steam or hot water in the shell. An integral internal controller shall be provided, anticipating a change in demand so that the final temperature can be maintained under all normal load conditions when used in conjunction with pneumatic control system or pilot-operated temperature control system. Normal load conditions shall be as specified by the manufacturer for the heater. Unit shall be manufactured in accordance with ASME BPVC SEC VIII D1, and shall be certified for 1.03 MPa (150 psi) working pressure in the shell and 1.03 MPa (150 psi) working pressure in the coils. Shell shall be carbon steel with copper lining. Heads shall be cast iron, bronze, or carbon steel plate with copper lining. Coils shall be copper or copper-nickel. Shell shall have metal sheathed fiberglass insulation, combination pressure and temperature relief valve, and thermometer. Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.10.3 Electric Instantaneous Water Heaters (Tankless)

UL 499 and UL listed flow switch activated, tankless electric instantaneous water heater for wall mounting below sink or lavatory.

2.10.4 Phenolic Resin Coatings for Heater Tubes

The phenolic resin coating system shall be applied at either the coil or coating manufacturer's factory in accordance with manufacturer's standard proven production process. The coating system shall be a product specifically intended for use on the material the water heating tubes/coils are made of and shall be acceptable for use in potable water systems. The coating system shall be capable of withstanding temperatures up to 204 degrees C (400 degrees F) dry bulb; and meet the requirements of 21 CFR 175.

The entire exterior surface and the first 125 mm to 200 mm (5 to 8 inches) inside the tubes of each coil shall be coated with phenolic resin coating system.

2.10.4.1 Standard Product

Provide a phenolic resin coating system that is a standard product of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship.

Standard products are defined as components and equipment that have been in satisfactory commercial or industrial use in similar applications of similar size for at least two years before bid opening.

Prior to this two year period, these standard products were sold on the commercial market using advertisements in manufacturers' catalogs or brochures. These manufacturers' catalogs, or brochures shall have been copyrighted documents or be identified with a manufacturer's document number.

2.11 HOT-WATER STORAGE TANKS

Hot-water storage tanks shall be constructed by one manufacturer, ASME stamped for the working pressure, and shall have the National Board (ASME) registration. The tank shall be cement-lined or glass-lined steel type in accordance with AWWA D100. The heat loss shall conform to TABLE III as determined by the requirements of ASHRAE 90.1 - SI (ASHRAE 90.1 - IP). Each tank shall be equipped with a thermometer, conforming to ASTM E1, Type I, Class 3, Range C, style and form as required for the installation, and with 175 mm (7 inch) scale. Thermometer shall have a separable socket suitable for a 20 mm (3/4 inch) tapped opening. Tanks shall be equipped with a pressure gauge 155 mm (6 inch) minimum diameter face. Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Storage tank capacity shall be as shown.

2.12 PUMPS

2.12.1 Sump Pumps

Sump pumps shall be of capacities indicated. The pumps shall be of the automatic, electric motor-driven, submerged type, complete with necessary control equipment and with a split or solid cast-iron or steel cover plate. The pumps shall be direct-connected by an approved flexible coupling to a vertical electric motor having a continuous oiling device or packed bearings sealed against dirt and moisture. Motors shall be totally enclosed, fan-cooled of sizes as indicated and shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 or 4 enclosure. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Each pump shall be fitted with a high-grade thrust bearing mounted above the floor. Each shaft shall have an alignment bearing at each end, and the suction inlet shall be between 75 and 150 mm (3 and 6 inches) above the sump bottom. The suction side of each pump shall have a strainer of ample capacity. A float switch assembly, with the switch completely enclosed in a NEMA 250, Type 1 or 4 enclosure, shall start and stop each motor at predetermined water levels. Duplex pumps shall be equipped with an automatic alternator to change the lead operation from one pump to the other, and for starting the second pump if the flow exceeds the capacity of the first pump. The discharge line from each pump shall be provided with a union or flange, a nonclog swing check valve, and a stop valve in an accessible location near the pump.

2.12.2 Circulating Pumps

Domestic hot water circulating pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump and motor shall be integrally mounted on a cast-iron or steel subbase, close-coupled with an overhung impeller, or supported by the piping on which it is installed. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze.

Motor shall be totally enclosed, fan-cooled and shall have sufficient wattage (horsepower) for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover.

Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Pump motors smaller than 746 W (1 hp Fractional horsepower pump motors) shall have integral thermal overload protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Guards shall shield exposed moving parts.

2.12.3 Booster Pumps

2.12.3.1 Centrifugal Pumps

Horizontal split-case centrifugal-type booster pumps shall be furnished. The capacities shall be as shown, and the speed shall not exceed 1800 rpm. Pumps shall have a casing of close-grained iron or steel with smooth water passages. A gasket shall be provided between the upper and lower halves of the casing. Suction and discharge connections shall be flanged. Impellers shall be nonoverloading, bronze, balanced to eliminate vibration, and shall be keyed to corrosion-resisting steel shafts. The casings shall be fitted with bronze wearing or sealing rings. Bearings shall be cartridge type, enabling the entire rotating element to be removed without disturbing alignment or exposing the bearings to dirt, water, and other foreign matter. Pumps shall be provided with mechanical seals. Seal boxes shall be machined in the pump casing and at both sides of the pump, and shall be of sufficient depth to include a conventional bronze seal ring and rows of shaft packing. Bedplates shall be close-grain cast iron or steel with ribs and lugs, complete with foundation bolts, and shall have a drip lip with drain hole. Each pump shall be tested at the manufacturer's plant for operating characteristics at the rated capacity and under specified operating conditions. Test curves shall be furnished showing capacity in liters per second (gpm), head in meters (feet), efficiency, brake wattage (horsepower), and operation in parallel with similar pumps. Multiple pump installations shall have pump characteristics compatible for operation in parallel with similar pumps. The electric motor shall be sized for non-overload when operating at any point along the characteristic curve of the pump. Guards shall shield exposed belts and moving parts.

2.12.3.2 Controls

Each pump motor shall be provided with enclosed across-the-line-type magnetic controller complete in a NEMA 250 Type 1 enclosure with three position, "HAND-OFF-AUTOMATIC," selector switch in cover. Pumps shall be automatically started and stopped by float or pressure switches, as indicated. The pumps shall start and stop at the levels and pressures indicated. A multiposition sequence selector switch shall be provided so that any two pumps may be operated simultaneously beeping a third pump as a standby.

2.12.4 Flexible Connectors

Flexible connectors shall be provided at the suction and discharge of each pump that is 1 hp or larger. Connectors shall be constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Flexible connectors shall be line size and suitable for the pressure and temperature of the intended service.

2.12.5 Sewage Pumps

Provide single type duplex type with automatic controls to alternate the operation from one pump to the other pump and to start the second pump in the event the first pump cannot handle the incoming flow. Provide high water alarm and check valve.

2.13 WATER PRESSURE BOOSTER SYSTEM

2.13.1 Constant Speed Pumping System

Constant speed pumping system with pressure-regulating valves shall employ one lead pump for low flows, and one or more lag pumps for higher flows. Pressure-regulating valves shall be provided with nonslam check feature. The factory prepiped and prewired assembly shall be mounted on a steel frame, complete with pumps, motors, and automatic controls. The system capacity and capacity of individual pumps shall be as indicated. Current sensing relays shall provide staging of the pumps. The pumps shall be protected from thermal buildup, when running at no-flow, by a common thermal relief valve. Pressure gauges shall be mounted on the suction and discharge headers. The control panel shall bear the UL listing label for industrial control panels and shall be in a NEMA 250, Type 1 enclosure. The control panel shall include the following: No-flow shutdown; 7-day time clock; audiovisual alarm; external resets; manual alternation; magnetic motor controllers; time delays; transformer; current relays; "HAND-OFF-AUTOMATIC" switches for each pump; minimum run timers; low suction pressure cutout; and indicating lights for power on, individual motor overload, and low suction pressure. The control circuit shall be interlocked so that the failure of any controller shall energize the succeeding controller.

2.13.2 Hydro-Pneumatic Water Pressure System

An ASME code constructed tank stamped for 862 kPa (125 psig) water working pressure shall be provided. The tank shall have a flexible diaphragm made of material conforming to FDA requirements for use with potable water and shall be factory precharged to meet required system pressure.

2.13.3 Variable Speed Pumping System

Variable speed pumping system shall provide system pressure by varying speed and number of operating pumps. The factory prepiped and prewired assembly shall be mounted on a steel frame complete with pumps, variable speed drives, motors, and controls. The variable speed drives shall be the oil-filled type capable of power transmission throughout their complete speed range without vibration, noise, or shock loading. Each variable speed drive shall be run-tested by the manufacturer for rated performance, and the manufacturer shall furnish written performance certification. System shall have suppressors to prevent noise transmission over electric feed lines. Required electrical control circuitry and system function sensors shall be supplied by the variable speed drive manufacturer. The primary power controls and magnetic motor controllers shall be installed in the controls supplied by the drive manufacturer or the motor control center. The sensors shall be located in the system to control drive speed as a function of constant pump discharge pressure or constant system pressure at location indicated. Connection between the sensors and the variable speed drive controls shall be accomplished with hydraulic sensing lines, copper wiring, or telemetry. Controls shall be in NEMA 250, Type 1 enclosures.

2.14 DOMESTIC WATER SERVICE METER

Cold water meters 50 mm (2 inches) and smaller shall be positive displacement type conforming to AWWA C700. Cold water meters 64 mm (2-1/2 inches) and larger shall be turbine type conforming to AWWA C701. Meter register may be round or straight reading type, as provided by the local utility. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories.

2.15 POOL WATER PUMP SAFETY VACUUM RELEASE SYSTEM (SVRS)

Safety vacuum release system (SVRS) shall meet the requirements specified in ASME A112.19.17, or ASTM F2387, as modified and supplemented by this specification. System shall include:

Vacuum monitoring at least 60 times per second.
Power supply monitoring at least 50 times per second.
Capable of integration with existing timer box.
Low vacuum sensing and alarm.
Maintenance override.

Power back-up.
Display of error readout.
Turns off power to pump in milliseconds upon detecting sudden vacuum change.
Multiple audible alarm capabilities for multiple harmful situations.

2.16 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, corresponding to the applications in accordance with NEMA MG 11. In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors with continuous ratings, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Controllers and contactors shall have auxiliary contacts for use with the controls provided. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers, including the required monitors and timed restart.

Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.17 MISCELLANEOUS PIPING ITEMS

2.17.1 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated on copper alloy plates or polished stainless steel finish in finished spaces. Provide paint finish on plates in unfinished spaces.

2.17.2 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Sleeves are not required where supply drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade, except where penetrating a membrane waterproof floor.

2.17.2.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.17.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.17.3 Pipe Hangers (Supports)

Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

2.17.4 Nameplates

Provide 3.2 mm (0.125 inch) thick melamine laminated plastic nameplates, black matte finish with white center core, for equipment, gages, thermometers, and valves; valves in supplies to faucets will not require nameplates. Accurately align lettering and engrave minimum of 6.4 mm (0.25 inch) high normal block lettering into the white core. Minimum size of nameplates shall be 25 by 63 mm (1.0 by 2.5 inches). Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule.

2.17.5 Labels

Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:

a. Identification of the sensor and its operation with graphic, written, or Braille description.

b. Range of the sensor.

c. Battery replacement schedule.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Piping located in shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA Fire Man. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 1.5 m (5 feet) outside the building, unless otherwise indicated. A gate valve, full port ball valve, or ball valve and drain shall be installed on the water service line inside the building approximately 150 mm (6 inches) above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 300 mm (12 inches) below the average local frost depth or finish grade or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 12 mm (1/2 inch) between finished covering on the different services. Bare and insulated water lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of 20 mm (3/4 inch) hose bibb with renewable seat and gate, full port ball, or ball valve ahead of hose bibb. At other low points, 20 mm (3/4 inch) brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets, changes in direction, etc., where indicated and/or required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 15 m (50 feet) in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends . Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Thrust Restraint

Plugs, caps, tees, valves and bends deflecting 11.25 degrees or more, either vertically or horizontally, in waterlines 100 mm (4 inches) in diameter or larger shall be provided with thrust blocks, where indicated, to prevent movement. Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 14 MPa (2000 psi) after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust block shall be poured against undisturbed earth. The side of the thrust block not subject to thrust shall be poured against forms. The area of bearing will be as shown. Blocking shall be placed so that the joints of the fitting are accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.1.8 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to ASSE 1010. Vertical capped pipe columns will not be permitted.

3.1.2 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.2.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.2.2 Mechanical Couplings

Mechanical couplings may be used in conjunction with grooved pipe for aboveground, ferrous or non-ferrous, domestic hot and cold water systems, in lieu of unions, brazed, soldered, welded, flanged, or threaded joints.

Mechanical couplings are permitted in accessible locations including behind access plates. Flexible grooved joints will not be permitted, except as vibration isolators adjacent to mechanical equipment. Rigid grooved joints shall incorporate an angle bolt pad design which maintains metal-to-metal contact with equal amount of pad offset of housings upon installation to ensure positive rigid clamping of the pipe.

Designs which can only clamp on the bottom of the groove or which utilize gripping teeth or jaws, or which use misaligned housing bolt holes, or which require a torque wrench or torque specifications will not be permitted.

Rigid grooved pipe couplings shall be for use with grooved end pipes, fittings, valves and strainers. Rigid couplings shall be designed for not less than 862 kPa (125 psi) service and appropriate for static head plus the pumping head, and shall provide a watertight joint.

Grooved fittings and couplings, and grooving tools shall be provided from the same manufacturer. Segmentally welded elbows shall not be used. Grooves shall be prepared in accordance with the coupling manufacturer's latest published standards. Grooving shall be performed by qualified grooving operators having demonstrated proper grooving procedures in accordance with the tool manufacturer's recommendations.

The Contracting Officer shall be notified 24 hours in advance of test to demonstrate operator's capability, and the test shall be performed at the work site, if practical, or at a site agreed upon. The operator shall demonstrate the ability to properly adjust the grooving tool, groove the pipe, and to verify the groove dimensions in accordance with the coupling manufacturer's specifications.

3.1.2.3 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 65 mm (2-1/2 inches) and smaller; flanges shall be used on pipe sizes 80 mm (3 inches) and larger.

3.1.2.4 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.1.2.5 Cast Iron Soil, Waste and Vent Pipe

Bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping shall be installed per the manufacturer's recommendations.

3.1.2.6 Copper Tube and Pipe

a. Brazed. Brazed joints shall be made in conformance with AWS B2.2/B2.2M, ASME B16.50, and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.

b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 50 mm (2 inches) and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015. Soldered joints shall not be used in compressed air piping between the air compressor and the receiver.

c. Copper Tube Extracted Joint. Mechanically extracted joints shall be made in accordance with ICC IPC.

d. Press connection. Copper press connections shall be made in **strict** accordance with the manufacturer's installation instructions for manufactured rated size. The joints shall be pressed using the tool(s) approved by the manufacturer **of that joint**. Minimum distance between fittings shall be in accordance with the manufacturer's requirements.

3.1.2.7 Plastic Pipe

Acrylonitrile-Butadiene-Styrene (ABS) pipe shall have joints made with solvent cement. PVC and CPVC pipe shall have joints made with solvent cement elastomeric, threading, (threading of Schedule 80 Pipe is allowed only where required for disconnection and inspection; threading of

Schedule 40 Pipe is not allowed), or mated flanged.

3.1.2.8 Glass Pipe

Joints for corrosive waste glass pipe and fittings shall be made with corrosion-resisting steel compression-type couplings with acrylonitrile rubber gaskets lined with polytetrafluoroethylene.

3.1.2.9 Corrosive Waste Plastic Pipe

Joints for polyolefin pipe and fittings shall be made by mechanical joint or electrical fusion coil method in accordance with ASTM D2657 and ASTM F1290. Joints for filament-wound reinforced thermosetting resin pipe shall be made in accordance with manufacturer's instructions. Unions or flanges shall be used where required for disconnection and inspection.

3.1.2.10 Polypropylene Pipe

Joints for polypropylene pipe and fittings shall be made by heat fusion welding socket-type or butt-fusion type fittings and shall comply with ASTM F2389.

3.1.3 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.4 Corrosion Protection for Buried Pipe and Fittings

Ductile iron, cast iron, and steel pipe, fittings, and joints shall have a protective coating. Additionally, ductile iron, cast iron, and steel pressure pipe shall have a cathodic protection system and joint bonding. The cathodic protection system, protective coating system, and joint bonding for cathodically protected pipe shall be in accordance with Section 26 42 14.00 10 CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE) and Section 26 42 17.00 10 CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT). Coatings shall be selected, applied, and inspected in accordance with NACE SP0169 and as otherwise specified. The pipe shall be cleaned and the coating system applied prior to pipe tightness testing. Joints and fittings shall be cleaned and the coating system applied after pipe tightness testing. For tape coating systems, the tape shall conform to AWWA C203 and shall be applied with a 50 percent overlap. Primer utilized with tape type coating systems shall be as recommended by the tape manufacturer.

3.1.5 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.5.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.

A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve involved.

Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 100 mm (4 inches) above the finished floor.

Unless otherwise indicated, sleeves shall be of a size to provide a between 6 mm (1/4 inch) and 25 mm (one inch) clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic.

Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C920 and with a primer, backstop material and surface preparation as specified in Section 07 92 00 JOINT SEALANTS. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated.

Sleeves through below-grade walls in contact with earth shall be recessed 12 mm (1/2 inch) from wall surfaces on both sides. Annular space between pipe and sleeve shall be filled with backing material and sealants in the joint between the pipe and concrete or masonry wall as specified above. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls shall conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.1.5.2 Flashing Requirements

Pipes passing through roof shall be installed through a 4.9 kg per square meter (16 ounce) copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and shall be set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 250 mm (10 inches). For cleanouts, the flashing shall be turned down into the hub and caulked after placing the ferrule. Pipes passing through pitched roofs shall be flashed, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 200 mm (8 inches) from the pipe in all directions and lapped into the roofing to provide a watertight seal. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint. Pipes, up to and including 250 mm (10 inches) in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.5.3 Waterproofing

Waterproofing at floor-mounted water closets shall be accomplished by forming a flashing guard from soft-tempered sheet copper. The center of the sheet shall be perforated and turned down approximately 40 mm (1-1/2 inches) to fit between the outside diameter of the drainpipe and the inside diameter of the cast-iron or steel pipe sleeve. The turned-down portion of the flashing guard shall be embedded in sealant to a depth of approximately 40 mm (1-1/2 inches); then the sealant shall be finished off flush to floor level between the flashing guard and drainpipe. The flashing guard of sheet copper shall extend not less than 200 mm (8 inches) from the drainpipe and shall be lapped between the floor membrane in a solid coating of bituminous cement. If cast-iron water closet floor flanges are used, the space between the pipe sleeve and drainpipe shall be sealed with sealant and the flashing guard shall be upturned approximately 40 mm (1-1/2 inches) to fit the outside diameter of the drainpipe and the inside diameter of the water closet floor flange. The upturned portion of the sheet fitted into the floor flange shall be sealed.

3.1.5.4 Optional Counterflashing

Instead of turning the flashing down into a dry vent pipe, or caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by utilizing the following:

a. A standard roof coupling for threaded pipe up to 150 mm (6 inches) in diameter.

b. A tack-welded or banded-metal rain shield around the pipe.

3.1.5.5 Pipe Penetrations of Slab on Grade Floors

Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs Flashing Requirements and Waterproofing, a groove 6 to 13 mm (1/4 to 1/2 inch) wide by 6 to 10 mm (1/4 to 3/8 inch) deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07 92 00 JOINT SEALANTS.

3.1.5.6 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.6 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.1.7 Supports

3.1.7.1 General

Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.7.2 Pipe Supports and Structural Bracing, Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and Section 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as shown. Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided. Material used for supports shall be as specified in Section 05 12 00 STRUCTURAL STEEL, Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS, Section 05 51 33 METAL LADDERS, Section 05 52 00 METAL RAILINGS, or Section 05 51 00 METAL STAIRS.

3.1.7.3 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and shall have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Type 39 saddles shall be used on insulated pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C (60 degrees F) or higher. Type 39 saddles shall be welded to the pipe.

h. Type 40 shields shall:

(1) Be used on insulated pipe less than 100 mm (4 inches).

(2) Be used on insulated pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C (60 degrees F) or less.

(3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 128 kg per cubic meter (8 pcf) or greater.

i. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe shall be 49 degrees C (120 degrees F) for PVC and 82 degrees C (180 degrees F) for CPVC. Horizontal pipe runs shall include allowances for expansion and contraction.

j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than 4.5 m (15 feet) nor more than 2 m (8 feet) from end of risers, and at vent terminations. Vertical pipe risers shall include allowances for expansion and contraction.

k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:

(1) On pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C (60 degrees F) or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.

(2) On pipe less than 100 mm (4 inches) a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

(3) On pipe 100 mm (4 inches) and larger carrying medium less that 15 degrees C (60 degrees F) a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.

m. Where there are high system temperatures and welding to piping is not desirable, the type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches) or by an amount adequate for the insulation, whichever is greater.

n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.7.4 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floor or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3.1.8 Welded Installation

Plumbing pipe weldments shall be as indicated. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.9 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 100 mm (4 inches) will not be required. A cleanout installed in connection with cast-iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place shown. An extra-heavy cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug shall be caulked into the hub of the fitting and shall be flush with the floor. Cleanouts in connection with other pipe, where indicated, shall be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except plastic plugs shall be installed in plastic pipe. Plugs shall be the same size as the pipe up to and including 100 mm (4 inches). Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drain where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 450 mm (18 inches) of crawl space is provided under the floor. Cleanouts on pipe concealed in partitions shall be provided with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Round access covers shall be provided and secured to plugs with securing screw.

Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls shall have access covers and frames installed flush with the finished wall. Cleanouts installed in finished floors subject to foot traffic shall be provided with a chrome-plated cast brass, nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws shall not project above the cover surface. Where cleanouts are provided with adjustable heads, the heads shall be cast iron or plastic.

3.2 WATER HEATERS AND HOT WATER STORAGE TANKS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater or storage tank. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the tank or heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 150 mm (6 inches) above the top of the tank or water heater.

3.2.2 Installation of Gas- and Oil-Fired Water Heater

Installation shall conform to NFPA 54 for gas fired and NFPA 31 for oil fired. Storage water heaters that are not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps directly on both the inlet and outlet. Circulating systems need not have heat traps installed. An acceptable heat trap may be a piping arrangement such as elbows connected so that the inlet and outlet piping make vertically upward runs of not less than 600 mm (24 inches) just before turning downward or directly horizontal into the water heater's inlet and outlet fittings. Commercially available heat traps, specifically designed by the manufacturer for the purpose of effectively restricting the natural tendency of hot water to rise through vertical inlet and outlet piping during standby periods may also be approved.

3.2.3 Heat Traps

Piping to and from each water heater and hot water storage tank shall be routed horizontally and downward a minimum of 600 mm (2 feet) before turning in an upward direction.

3.2.4 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.5 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Flushometer valves for water closets shall be installed 1 m (39 inches) above the floor, except at water closets intended for use by the physically handicapped where flushometer valves shall be mounted at approximately 760 mm (30 inches) above the floor and arranged to avoid interference with grab bars. In addition, for water closets intended for handicap use, the flush valve handle shall be installed on the wide side of the enclosure. Bumpers for water closet seats shall be installed on the wall, flushometer stop, or flushometer spud.

3.3.3 Height of Fixture Rims Above Floor

Lavatories shall be mounted with rim 775 mm (31 inches) above finished floor. Wall-hung drinking fountains and water coolers shall be installed with rim 1020 mm (42 inches) above floor. Wall-hung service sinks shall be mounted with rim 700 mm (28 inches) above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with ICC A117.1.

3.3.4 Shower Bath Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate shall be made watertight by caulking or gasketing.

3.3.5 Fixture Supports

Fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.5.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.5.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.5.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.5.4 Support for Wood Stud Construction

Where floor is a concrete slab, a floor-anchored chair carrier shall be used. Where entire construction is wood, wood crosspieces shall be installed. Fixture hanger plates, supports, brackets, or mounting lugs shall be fastened with not less than No. 10 wood screws, 6 mm (1/4 inch) thick minimum steel hanger, or toggle bolts with nut. The wood crosspieces shall extend the full width of the fixture and shall be securely supported.

3.3.5.5 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, reinforced wax, treated felt, or neoprene gaskets shall be provided. The type of gasket furnished shall be as recommended by the chair-carrier manufacturer.

3.3.6 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with ICC IPC at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged.

Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.7 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS, Section 05 51 33 METAL LADDERS, Section 05 52 00 METAL RAILINGS, or Section 05 51 00 METAL STAIRS.

3.3.8 Sight Drains

Sight drains shall be installed so that the indirect waste will terminate 50 mm (2 inches) above the flood rim of the funnel to provide an acceptable air gap.

3.3.9 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on cast-iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps installed on plastic pipe may be plastic conforming to ASTM D3311. Traps for acid-resisting waste shall be of the same material as the pipe.

3.3.10 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.10.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 150 mm (6 inches) for turnup on walls or partitions, and shall be folded over the curb with an approximate return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nail heads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.3.10.2 Metal Shower Pans

When a shower pan of required size cannot be furnished in one piece, metal pieces shall be joined with a flintlock seam and soldered or burned. The corners shall be folded, not cut, and the corner seam shall be soldered or burned. Pans, including upstands, shall be coated on all surfaces with one brush coat of asphalt. Asphalt shall be applied evenly at not less than 1 liter per square meter (1 gallon per 50 square feet). A layer of felt covered with building paper shall be placed between shower pans and wood floors. The joining surfaces of metal pan and drain shall be given a brush coat of asphalt after the pan is connected to the drain.

3.3.10.3 Nonplasticized Chlorinated Polyethylene Shower Pans

Corners of nonplasticized chlorinated polyethylene shower pans shall be folded against the upstand by making a pig-ear fold. Hot-air gun or heat lamp shall be used in making corner folds. Each pig-ear corner fold shall be nailed or stapled 12 mm (1/2 inch) from the upper edge to hold it in place. Nails shall be galvanized large-head roofing nails. On metal framing or studs, approved duct tape shall be used to secure pig-ear fold and membrane. Where no backing is provided between the studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding 12 mm (1/2 inch) from upper edge. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it will be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Surfaces to be solvent-welded shall be clean. Surfaces to be joined with xylene shall be initially sprayed and vigorously cleaned with a cotton cloth, followed by final coating of xylene and the joining of the surfaces by roller or equivalent means. If ambient or membrane temperatures are below 4 degrees C (40 degrees F) the membrane and the joint shall be heated prior to application of xylene. Heat may be applied with hot-air gun or heat lamp, taking precautions not to scorch the membrane. Adequate ventilation and wearing of gloves are required when working with xylene. Membrane shall be pressed into position on the drain body, and shall be cut and fit to match so that membrane can be properly clamped and an effective gasket-type seal provided. On wood subflooring, two layers of 0.73 kg per square meter (15 pound) dry felt shall be installed prior to installation of shower pan to ensure a smooth surface for installation.

3.3.10.4 Nonplasticized Polyvinyl Chloride (PVC) Shower Pans

Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 150 mm (6 inches) in room areas and 75 mm (3 inches) above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 25 mm (1 inch) of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To ensure adherence of the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly. A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 50 mm (2 inches). Top edge shall be folded back and surface primed with a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 600 or 900 mm (2 or 3 feet) at a time shall be welded. On wood subflooring, two layers of 0.73 kg per square meter (15 pound) felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Piping connected to mechanical equipment shall be provided with flexible connectors. Isolation unit installation shall limit vibration to 10 percent of the lowest equipment rpm.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 35 mm (1-3/8 inch) minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of operable components which are not visible from the finished space and installed in the space directly above the suspended grid ceiling. The operable components shall include valves, dampers, switches, linkages and thermostats. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 12 mm (3/8 inch) in diameter and secured to removable ceiling panels with fasteners. The fasteners shall be inserted into the ceiling panels so that the fasteners will be concealed from view. The fasteners shall be manually removable without tools and shall not separate from the ceiling panels when panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall have the approximate dimensions of 1 m (3 foot) width, 750 mm (30 inches) height, and 12 mm (1/2 inch) thickness. The board shall be made of wood fiberboard and framed under glass or 1.6 mm (1/16 inch) transparent plastic cover. Unless otherwise directed, the color code symbols shall be approximately 20 mm (3/4 inch) in diameter and the related lettering in 12 mm (1/2 inch) high capital letters. The color code board shall be mounted and located in the mechanical or equipment room. The color code system shall be as indicated on the drawings.

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.8.1 Painting of New Equipment

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.8.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 3 mm (0.125 inch) on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C (120 degrees F), the factory painting system shall be designed for the temperature service.

3.8.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 50 degrees C (120 degrees F) shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 50 Degrees C (120 Degrees F): Immediately after cleaning, the metal surfaces subject to temperatures less than 50 degrees C (120 degrees F) shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm (0.3 mil), one coat of primer applied to a minimum dry film thickness of 0.0255 mm (one mil); and two coats of enamel applied to a minimum dry film thickness of 0.0255 mm (one mil) per coat.

b. Temperatures Between 50 and 205 Degrees C (120 and 400 Degrees F): Metal surfaces subject to temperatures between 50 and 205 degrees C (120 and 400 degrees F) shall receive two coats of 205 degrees C (400 degrees F) heat-resisting enamel applied to a total minimum thickness of 0.05 mm (2 mils).

c. Temperatures Greater Than 205 Degrees C (400 Degrees F): Metal surfaces subject to temperatures greater than 205 degrees C (400 degrees F) shall receive two coats of 315 degrees C (600 degrees F) heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm (2 mil).

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC IPC, except that the drainage and vent system final test shall include the smoke test. The Contractor has the option to perform a peppermint test in lieu of the smoke test. If a peppermint test is chosen, the Contractor must submit a testing procedure to the Contracting Officer for approval.

a. Drainage and Vent Systems Test. The final test shall include a smoke test.

b. Building Sewers Tests.

c. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies.

Backflow prevention assembly test gauges shall be tested annually for accuracy in accordance with the requirements of State or local regulatory agencies. If there is no State or local regulatory agency requirements, gauges shall be tested annually for accuracy in accordance with the requirements of University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14), or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention assembly test gauges. Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	
Test Pressure Readings	Serial Number and Test Data of Gauges

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 25 mm (1 inch) for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with hot potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 1.2 meters per second (4 fps) through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration. All faucets and drinking water fountains, to include any device considered as an end point device by NSF/ANSI 61, Section 9, shall be flushed a minimum of 1 L (0.25 gallons) per 24 hour period, ten times over a 14 day period.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation according to manufacturer's instructions. Comply with ASHRAE 90.1 - SI (ASHRAE 90.1 - IP) for minimum efficiency requirements. Unless more stringent local requirements exist, lead levels shall not exceed limits established by 40 CFR 141.80 (c)(1). The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

e. Pump suction and discharge pressures.

f. Temperature of each domestic hot-water supply.

g. Operation of each floor and roof drain by flooding with water.

h. Operation of each vacuum breaker and backflow preventer.

i. Complete operation of each water pressure booster system, including pump start pressure and stop pressure.

3.9.5 Disinfection

After all system components are provided and operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. Before introducing disinfecting chlorination material, entire system shall be flushed with potable water until any entrained dirt and other foreign materials have been removed.

Water chlorination procedure shall be in accordance with AWWA C651 and AWWA C652 as modified and supplemented by this specification. The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). Feed a properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or inject liquid chlorine into the system through a solution-feed chlorinator and booster pump until the entire system is completely filled.

Test the chlorine residual level in the water at 6 hour intervals for a continuous period of 24 hours. If at the end of a 6 hour interval, the chlorine residual has dropped to less than 25 ppm, flush the piping including tanks with potable water, and repeat the above chlorination procedures. During the chlorination period, each valve and faucet shall be opened and closed several times.

After the second 24 hour period, verify that no less than 25 ppm chlorine residual remains in the treated system. The 24 hour chlorination procedure must be repeated until no less than 25 ppm chlorine residual remains in the treated system.

Upon the specified verification, the system including tanks shall then be flushed with potable water until the residual chlorine level is reduced to less than one part per million. During the flushing period, each valve and faucet shall be opened and closed several times.

Take addition samples of water in disinfected containers, for bacterial examination, at locations specified by the Contracting Officer
Test these samples for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with EPA SM 9223 AWWA 10084. The testing method used shall be EPA approved for drinking water systems and shall comply with applicable local and state requirements.

Disinfection shall be repeated until bacterial tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 WASTE MANAGEMENT

Place materials defined as hazardous or toxic waste in designated containers. Return solvent and oil soaked rags for contaminant recovery and laundering or for proper disposal. Close and seal tightly partly used sealant and adhesive containers and store in protected, well-ventilated, fire-safe area at moderate temperature. Place used sealant and adhesive tubes and containers in areas designated for hazardous waste. Separate copper and ferrous pipe waste in accordance with the Waste Management Plan and place in designated areas for reuse.

3.11 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.12 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, minimum overall efficiency.

ET = Minimum thermal efficiency with 21 degrees C (70 degrees F) delta T.

SL = Standby loss is maximum (Btu/h) based on a 38.9 degree C (70 degrees F) temperature difference between stored water and ambient requirements.

V = Rated volume in gallons

Q = Nameplate input rate in kW (Btu/h)

3.12.1 Storage Water Heaters

3.12.1.1 Electric

a. Storage capacity of 227 liters (60 gallons) shall have a minimum energy factor (EF) of 0.93 or higher per FEMP requirements.

b. Storage capacity of 227 liters (60 gallons) or more shall have a minimum energy factor (EF) of 0.91 or higher per FEMP requirements.

3.12.1.2 Gas

a. Storage capacity of 189 liters (50 gallons) or less shall have a minimum energy factor (EF) of 0.62 or higher per FEMP requirements.

b. Storage capacity of 75.7 liters (20 gallons) - or more and input rating of 22980 W (75,000 Btu/h) or less: minimum EF shall be 0.62 - 0.0019V per 10 CFR 430.

c. Rating of less than 22980 W: (75,000 Btu/h) ET shall be 80 percent; maximum SL shall be (0/800+100x(V^^1/2)), per ANSI Z21.10.3/CSA 4.3

3.12.1.3 Oil

a. Storage capacity of 75.7 liters (20 gallons) or more and input rating of 30773 W (105,000 Btu/h) or less: minimum EF shall be 0.59-0.0019V per 10 CFR 430.

b. Rating of less than 309.75 W/L (4,000 Btu/h/gallon) or input rating more than 30773 W: (105,000 Btu/h:) ET shall be 78 percent; maximum SL shall be (Q/800+100x(V^^1/2)), per ANSI Z21.10.3/CSA 4.3.

3.12.2 Unfired Hot Water Storage

All volumes and inputs: shall meet or exceed R-12.5.

3.12.3 Instantaneous Water Heater

3.12.3.1 Gas

a. Rating of 309.75 W/L (4,000 Btu/h/gal) and greater and less than 7.57 L (2 gallons) with an input greater than 14.66 kW (50,000 Btu/h) and less than 58.62 kW (200,000 Btu/h) shall have a minimum energy factor (EF) of 0.62-0.0019V per 10 CFR 430.

b. Rating of 309.75 W/L (4,000 Btu/h/gal) and greater and less than 37.85 L (10 gallons) with an input of 58.62 kW (200,000 Btu/h) and greater shall have a minimum thermal efficiency (ET) of 80 percent per ANSI Z21.10.3/CSA 4.3

c. Rating of 309.75 W/L (4,000 BTU/h/gal) and greater and 37.85 L (10 gallons) and greater with an input of 58.62 kW (200,000 Btu/h) and greater shall have a minimum thermal efficiency (ET) of 80 percent and the maximum SL shall be Q/800+110x(V^^1/2)) per ANSI Z21.10.3/CSA 4.3

3.12.3.2 Oil

a. Rating of 309.75 W/L (4,000 Btu/h/gal) and greater and less than 7.57 L (2 gallons) with an input of 61.55 kW (210,000 Btu/h) and less shall have an energy factor (EF) of 0.59-0.0019V per 10 CFR 430

b. Rating of 309.75 W/L (4,000 Btu/h/ga) l and greater and less than 37.85 L (10 gallons) with an input greater than 61.55 kW (210,000 Btu/h) shall have a minimum thermal efficiency (ET) of 80 percent per ANSI Z21.10.3/CSA 4.3

c. Rating of 309.75 W/L (4,000 Btu/h/ga)l and 37.85 L (10 gallons) and greater with an input of greater than 61.55 kW (210,000 Btu/h) shall have a minimum thermal efficiency (ET) of 78 percent and the maximum SL shall be Q/800+110x(V^^1/2)) per ANSI Z21.10.3/CSA 4.3

3.12.4 Pool Heaters

a. Gas/oil fuel, capacities and inputs: ET shall be 78 percent per ASHRAE 146.

b. Heat Pump, All capacities and inputs shall meet a COP of 4.0 per ASHRAE 146

3.13 TABLES

TABLE I							
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, AND VENT PIPING SYSTEMS							
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F
1	Cast iron soil pipe and fittings, hub and spigot, ASTM A74 or KS D 4307 with compression gaskets. Pipe and fittings shall be marked with the CISPI trademark.	X	X	X	X	X	
2	Cast iron soil pipe and fittings hubless, CISPI 301 and ASTM A888 or KS D 4307. Pipe and fittings shall be marked with the CISPI trademark.		X	X	X	X	
3	Cast iron drainage fittings, threaded, ASME B16.12 or KS B 1532 for use with Item 10	X		X	X		
4	Cast iron screwed fittings (threaded) ASME B16.4 or KS B 1532 for use with Item 10				X	X	
5	Grooved pipe couplings, ferrous and non-ferrous pipe ASTM A536 and ASTM A47/A47M	X	X		X	X	
6	Ductile iron grooved joint fittings for ferrous pipe ASTM A536 and ASTM A47/A47M for use with Item 5	X	X		X	X	

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, AND VENT PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F
7	Bronze sand casting grooved joint pressure fittings for non-ferrous pipe ASTM B584, for use with Item 5	X	X		X	X	
8	Wrought copper grooved joint pressure pressure fittings for non-ferrous pipeASTM B75/B75M, C12200, ASTM B152/B152M, C11000, ASME B16.22 for use with Item 5	X	X				
9	Malleable-iron threaded fittings, galvanized ASME B16.3 or KS B 1531 for use with Item 10				X	X	
10	Steel pipe, seamless galvanized, ASTM A53/A53M, Type S, Grade B or KS D 3562	X			X	X	
11	Seamless red brass pipe, ASTM B43				X	X	
12	Bronzed flanged fittings, ASME B16.24 for use with Items 11 and 14				X	X	
13	Cast copper alloy solder joint pressure fittings, ASME B16.18for use with Item 14				X	X	
14	Seamless copper pipe, ASTM B42						X
15	Cast bronze threaded fittings, ASME B16.15				X	X	

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, AND VENT PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F
16	Copper drainage tube, (DWV), ASTM B306	X*	X	X*	X	X	
17	Wrought copper and wrought alloy solder-joint drainage fittings. ASME B16.29	X	X	X	X	X	
18	Cast copper alloy solder joint drainage fittings, DWV, ASME B16.23	X	X	X	X	X	
19	Acrylonitrile-Butadiene-Sty (ABS) plastic drain, waste, and vent pipe and fittings ASTM D2661, ASTM F628	X	X	X	X	X	X
20	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D2665, ASTM F891, (Sch 40) ASTM F1760 or KS M 3401, KS M 3402, KS M 3404, and KS M 3410	X	X	X	X	X	X
21	Process glass pipe and fittings, ASTM C1053						X
22	High-silicon content cast iron pipe and fittings (hub and spigot, and mechanical joint), ASTM A518/A518M		X			X	X
23	Polypropylene (PP) waste pipe and fittings, ASTM D4101						X

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, AND VENT PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F
24	Filament-wound reinforced thermosetting resin (RTRP) pipe, ASTM D2996						X

SERVICE:
A - Underground Building Soil, Waste and Storm Drain
B - Aboveground Soil, Waste, Drain In Buildings
C - Underground Vent
D - Aboveground Vent
E - Interior Rainwater Conductors Aboveground
F - Corrosive Waste And Vent Above And Belowground
* - Hard Temper

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
1	Malleable-iron threaded fittings:				
	a. Galvanized, ASME B16.3 or KS B 1531 for use with Item 4a	X	X	X	X
	b. Same as "a" but not galvanized for use with Item 4b			X	
2	Grooved pipe couplings, ferrous pipe ASTM A536 and ASTM A47/A47M, non-ferrous pipe, ASTM A536 and ASTM A47/A47M	X	X	X	
3	Ductile iron grooved joint fittings for ferrous pipe ASTM A536 and ASTM A47/A47M, for use with Item 2	X	X	X	

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
4	Steel pipe:				
	a. Seamless, galvanized, ASTM A53/A53M, Type S, Grade B or KS D 3562	X	X	X	X
	b. Seamless, black, ASTM A53/A53M, Type S, Grade B or KS D 3562			X	
5	Seamless red brass pipe, ASTM B43	X	X		X
6	Bronze flanged fittings, ASME B16.24 for use with Items 5 and 7	X	X		X
7	Seamless copper pipe, ASTM B42	X	X		X
8	Seamless copper water tube, ASTM B88, ASTM B88M, or KS D 5301	X**	X**	X**	X***
9	Cast bronze threaded fittings, ASME B16.15 for use with Items 5 and 7	X	X		X
10	Wrought copper and bronze solder-joint pressure fittings, ASME B16.22 or KS D 5578 for use with Items 5, 7 and 8	X	X	X	X
11	Cast copper alloy solder-joint pressure fittings, ASME B16.18 for use with Item 8	X	X	X	X
12	Bronze and sand castings groovedjoint pressure fittings for non-ferrous pipe ASTM B584, for use with Item 2	X	X	X	
13	Polyethylene (PE) plastic pipe, Schedules 40 and 80, based on outside diameter	X			X

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
14	Polyethylene (PE) plastic pipe (SDR-PR), based on controlled outside diameter, ASTM D3035	X			X
15	Polyethylene (PE) plastic pipe (SIDR-PR), based on controlled inside diameter, ASTM D2239	X			X
16	Butt fusion polyethylene (PE) plastic pipe fittings, ASTM D3261 for use with Items 14, 15, and 16	X			X
17	Socket-type polyethylene fittings for outside diameter-controlled polyethylene pipe, ASTM D2683 for use with Item 15	X			X
18	Polyethylene (PE) plastic tubing, ASTM D2737	X			X
19	Chlorinated polyvinyl chloride (CPVC) plastic hot and cold water distribution system, ASTM D2846/D2846M	X	X		X
20	Chlorinated polyvinyl chloride (CPVC) plastic pipe, Schedule 40 and 80, ASTM F441/F441M	X	X		X
21	Chlorinated polyvinyl chloride (CPVC) plastic pipe (SDR-PR) ASTM F442/F442M	X	X		X
22	Threaded chlorinated polyvinyl chloride (chloride CPVC) plastic pipe fittings, Schedule 80, ASTM F437, for use with Items 20, and 21	X	X		X

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
23	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings, Schedule 40, ASTM F438 for use with Items 20, 21, and 22	X	X		X
24	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings Schedule 80, ASTM F439 for use with Items 20, 21, and 22	X	X		X
25	Polyvinyl chloride (PVC) plastic pipe, Schedules 40, 80, and 120, ASTM D1785	X			X
26	Polyvinyl chloride (PVC) pressure-rated pipe (SDR Series), ASTM D2241	X			X
27	Polyvinyl chloride (PVC) plastic pipe fittings, Schedule 40, ASTM D2466	X			X
28	Socket-type polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D2467 for use with Items 26 and 27	X			X
29	Threaded polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D2464	X			X
30	Joints for IPS PVC pipe using solvent cement, ASTM D2672	X			X
31	Polypropylene (PP) plastic pipe and fittings; ASTM F2389	X	X		X
32	Steel pipeline flanges, MSS SP-44	X	X		

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
33	Fittings: brass or bronze; ASME B16.15, and ASME B16.18 ASTM B828	X	X		
34	Carbon steel pipe unions, socket-welding and threaded, MSS SP-83	X	X	X	
35	Malleable-iron threaded pipe unions ASME B16.39	X	X		
36	Nipples, pipe threaded ASTM A733	X	X	X	
37	Crosslinked Polyethylene (PEX) Plastic Pipe ASTM F877	X	X		X
38	Press Fittings: A - Cold Water Service Aboveground B - Hot and Cold Water Distribution 82 degrees C (180 degrees F) Maximum Aboveground C - Compressed Air Lubricated D - Cold Water Service Belowground Indicated types are minimum wall thicknesses. ** - Type L - Hard *** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors **** - In or under slab floors only brazed joints				

TABLE III				
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT				
FUEL	STORAGE CAPACITY LITERS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. STORAGE WATER HEATERS				
Elect.	227 max		10 CFR 430	EF = 0.93
Elect.	227 min		10 CFR 430	EF = 0.91

TABLE III				
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT				
FUEL	STORAGE CAPACITY LITERS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
Elect.	75.7 min.	12 kW max.	10 CFR 430	EF = 0.93-0.00132V minimum
Elect.	75.7 min. OR	12 kW min.	ANSI Z21.10.3/C (Addenda B)	SL = 20+35x(V^^1/2) maximum
Elect. Heat Pump		24 Amps or less and 250 Volts or less	10 CFR 430	EF = 0.93-0.00132V
Gas	189 max		10 CFR 430	EF = 0.62-0.0019V min
Gas	75.7 min.	22 kW max.	10 CFR 430	EF = 0.80-0.0019V minimum
Gas	309.75 W/L max.	22 kW max.	ANSI Z21.10.3/C	ET= 80 percent; SL = 1.3+38/V max.
Oil	75.7 min.	30.8 kW max.	10 CFR 430	EF = 0.59-0.0019V min
Oil	309.75 W/L max	30.8 kW	ANSI Z21.10.3/C	ET = 78 percent; SL = (Q/800+110x(V^^1/2)) maximum
B. Unfired Hot Water Storage, R = 2.2 minimum				
C. Instantaneous Water Heater				
Gas	309.75 W/L min.	14.66 kW min.	10 CFR 430	EF = 0.62-0.0019V and 7.57 L max 58.62 kW max.
Gas	309.75 W/L min.	58.62 kW min.	ANSI Z21.10.3/C	ET = 80 percent and 37.85 L max 58.62 kW max.
Gas	309.75 W/L min.	58.62 kW min.	ANSI Z21.10.3/C	ET = 80 percent and 37.85 L min. SL + (Q/800+110x(V^^1/2)
Oil	309.75 W/L min.	61.552 kW max.	10 CFR 430	EF = 0.59-0.0019V and 37.85 L max.

TABLE III				
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT				
FUEL	STORAGE CAPACITY LITERS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
Oil	309.75 W/L min.	61.552 kW max.	ANSI Z21.10.3/C	ET = 80 percent and 37.85 L min. SL + (Q/800+110x(V^^1/2)
Oil	309.75 W/L min.	61.552 kW max.	ANSI Z21.10.3/C	ET = 78 percent and 37.85 L max SL = (Q800+110x(V^^1/2))
D. Pool Heater				
Gas or Oil	All	All	ASHRAE 146	ET = 78 percent
Heat Pump All	All	All	ASHRAE 146	COP = 4.0
TERMS: EF = Energy factor, minimum overall efficiency. ET = Minimum thermal efficiency with 21 degrees C delta T. SL = Standby loss is maximum Watts based on a 38.9 degrees C temperature difference between stored water and ambient requirements. V = Rated storage volume in gallons Q = Nameplate input rate in Watts				

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. STORAGE WATER HEATERS				
Elect.	60 max.		10 CFR 430	EF = 0.93
Elect.	60 min.		10 CFR 430	EF = 0.91
Elect.	20 min.	12 kW max.	10 CFR 430	EF = 0.93-0.00132V minimum
Elect.	20 min.	12 kW max.	ANSI Z21.10.3/C (Addenda B)	SL = 20+35x(V^^1/2) maximum
Elect. Heat Pump		24 Amps or less and 250 Volts or less	10 CFR 430	EF = 0.93-0.00132V
Gas	50 max.		10 CFR 430	EF = 0.62
Gas	20 min.	75,000 Btu/h max.	10 CFR 430	EF = 80-0.0019V min.
Gas	1,000 (Btu/h)/gal max.	75,000 Btu/h	ANSI Z21.10.3/C	ET = 80 percent min. SL = 1.3+38/V max.
Oil	20 min.	105,000 Btu/h max.	10 CFR 430	EF = 0.80-0.0019V min.
Oil	4,000 (Btu/h)/gal max	105,000 Btu/h min.	ANSI Z21.10.3/C	ET = 78 percent; SL = 1.3+38/V max.
B. Unfired Hot Water Storage, R-12.5 min.				
C. Instantaneous Water Heater				
Gas	4,000 (btu/h)/gal and 2 gal max.	50,000 Btu/h min 200,000 Btu/h max.	10 CFR 430	EF = 0.62-0.0019V
Gas	4,000 (btu/h)/gal and 2 gal max.	200,000 Btu/h min.	ANSI Z21.10.3/C	ET = 80 percent

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
Gas	4,000 (btu/h)/gal and 2 gal max.	200,000 Btu/h min.	ANSI Z21.10.3/C	ET = 80 percent SL = (Q/800+110x(V^^1/2))
Oil	4,000 (btu/h)/gal and 2 gal max.	50,000 Btu/h min. 210,000 Btu/h max.	10 CFR 430	EF = 0.59-0.0019V SL = (Q/800+110x(V^^1/2))
Oil	4,000 (btu/h)/gal and 10 gal max.	210,000 Btu/h min.	ANSI Z21.10.3/C	ET = 80 percent
Oil	4,000 (btu/h)/gal and 10 gal max.	210,000 Btu/h min.	ANSI Z21.10.3/C	ET = 78 percent SL = (Q/800+110x(V^^1/2)) max.
D. Pool Heater				
Gas or Oil	All	All	ASHRAE 146	ET = 78 percent
Heat Pump All	All	All	ASHRAE 146	COP = 4.0

TERMS:

EF = Energy factor, minimum overall efficiency.
ET = Minimum thermal efficiency with 70 degrees F delta T.
SL = Standby loss is maximum Btu/h based on a 70 degree F temperature difference between stored water and ambient requirements.
V = Rated storage volume in gallons
Q = Nameplate input rate in Btu/h

3.14 OPERATION AND MAINTENANCE MANUALS

Submit one hard copy and one digital copy (.pdf - text searchable) of operation and maintenance manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

-- End of Section --

SECTION 22 31 00

WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE)
02/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2005) Standard Methods for the Examination of Water and Wastewater
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C700	(2009) Standard for Cold Water Meters - Displacement Type, Bronze Main Case
AWWA C701	(2012) Standard for Cold-Water Meters - Turbine Type for Customer Service
AWWA D102	(2014) Coating Steel Water-Storage Tanks

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and

	Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A6/A6M	(2014) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A666	(2010) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B43	(2014) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D3299	(2010) Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM E100	(2014) ASTM Hydrometers
ASTM E126	(2013a) Inspection and Verification of Hydrometers
ASTM F593	(2013a) Stainless Steel Bolts, Hex Cap Screws, and Studs

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General

	Requirements
NEMA MG 1	(2014) Motors and Generators

NSF INTERNATIONAL (NSF)

NSF/ANSI 61	(2014) Drinking Water System Components - Health Effects

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation

SD-03 Product Data

Softening Equipment
Spare Parts
Field Instructions

SD-06 Test Reports

Softening Equipment
Piping

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

1.3 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.4 EXTRA MATERIALS

a. Submit spare parts data for each different item of material and equipment, after approval of the detail drawings and not later than 1 month prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 year(s) of service.

b. Provide, for each type of equipment furnished, special tools necessary for adjustment, operation, maintenance, and disassembly; a grease gun or other lubricating device for each type of grease required; and one or more steel cases mounted on the wall complete with flat key locks, two keys, and clips or hooks to hold each tool in a convenient location. Tools shall be high-grade, smooth, forged, alloy, tool steel. Grease guns shall be lever type. Tools shall be delivered at the same time as the equipment and handed over on completion of the work.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

b. Pumps and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.2 SOFTENING EQUIPMENT

Performance specified shall refer to each unit and not to the battery as a whole. Submit a complete list of equipment and material, including manufacturer's descriptive and technical literature; performance charts and curves; catalog cuts; and installation instructions.

2.2.1 Softener Tank

Tank shall be of buttwelded steel construction conforming to the ASME BPVC SEC VIII D1. Tank and both sides of false bottom shall be lined with nontoxic epoxy or rubber conforming to AWWA D102. Coatings for potable water tanks shall also conform to NSF/ANSI 61. The upper head of each tank shall be provided with an access opening 101.6 or 279.4 mm (4 or 11 inches) by 152.4 or 381.0 mm (6 or 15 inches) or larger. Lower side shell of each tank shall be provided with an access opening 101.6 by 152.4 mm (4 by 6 inches) or larger. Tank shall have angle leg or skid supports of cast-iron or steel.

2.2.2 Underdrain System

A system shall be provided within the softener tank for collecting softened water and distributing backwash water. The system shall be header-lateral-distributor head, deflector-plate or false bottom type. Underdrain system shall distribute the backwash water uniformly over the entire filter area, and at such velocities that will prevent the channeling of the filter bed.

2.2.2.1 Header-Lateral-Distributor Head Type

Header-lateral-distributor head type shall consist of a central manifold or header, connected to laterals provided with strainer heads or strainers with openings placed radially so as to discharge horizontally or downward. System shall be supported by a steel plate or steel angles conforming to ASTM A666 with rubber or nontoxic epoxy linings or by concrete fill or gravel bed or directly on the bottom of the tank. Where the system will permit the loss of the exchange material during the filtering cycle, the system shall be provided with a gravel bed. All bolts and attaching hardware shall be stainless steel, conforming to ASTM F593. Headers and laterals shall be all red brass, conforming to ASTM B43 or polyvinyl chloride, conforming to ASTM D1785 or ASTM D2241. Strainer heads and strainers shall be manufactured of materials compatible with the header-lateral system, and shall be brass or stainless steel.

Laterals and strainer heads, after being placed, shall not protrude into the header or laterals.

2.2.2.2 Deflector-Plate Type

Deflector-plate type shall be cast-iron or steel, and rubber or nontoxic epoxy lined, fastened to the bottom of the tank, and arranged for discharge through radial slots. Pipe connection for softened water outlet or backwash inlet shall be on the underside between the deflector and the tank bottom. Deflector-plate type collector system shall be provided with a gravel bed.

2.2.2.3 False Bottom Type

False bottom type shall consist of a false bottom with attached strainers. Strainers and fasteners shall be brass or stainless steel. System shall be designed to eliminate the need for a supporting gravel bed.

2.2.3 Gravel Bed

Supporting bed shall be placed above the underdrain systems. Gravel shall be free from clay, loam, dirt, and calcareous or other foreign materials and shall be free of flat or elongated particles. Gravel bed shall be properly graduated to distribute the backwash water, to prevent loss of exchange materials, and to prevent migration of the material in the gravel bed during operation and backwashing. Gravel bed shall not be less than 230 mm (9 inches) in depth. Where the void size of the top layer of gravel is greater than the smallest particle size of the exchange material, a 75 mm (3 inch) layer of ilmenite or garnet sand shall be added to the gravel bed.

2.3 BRINE APPLICATION SYSTEM

A brine application system, comprising one or two tanks, shall be provided for each installation. Where two tanks are furnished, one tank shall serve as a salt saturator tank, and the other as a brine tank. Single tank units shall serve as a combined salt saturator and brine tank. Minimum capacity of the system shall be such as to provide sufficient salt storage for three regeneration cycles or 24-hour operation, whichever is greater.

2.3.1 Tanks

Each saturator, brine or combined-purpose tank shall be fabricated from steel conforming to ASTM A6/A6M not less than 4.8 mm (3/16 inch) thick, lined with enamel, or of fiber glass filament-wound reinforced plastic construction, conforming to ASTM D3299. Each tank shall be equipped with an underdrain system manufactured from polyvinyl chloride conforming to ASTM D1785 or ASTM D2241 or red brass conforming to ASTM B43 and provided with a layer of graded gravel or screens for filtering the brine. Screens shall be manufactured from polyvinyl chloride, brass, or stainless steel. Saturator tank or combined-purpose tank shall be equipped with a water inlet valve float-operated or solenoid-operated. Solenoid-operated valve shall be activated by a probe or a float-operated switch or a timer together with a float switch to automatically shut off the incoming supply in the event of failure of the timing mechanism. Water inlet valves and switches shall be mounted externally. Floats and probes may be mounted internally or externally, in such a manner that the stored salt shall not interfere with their operation. All devices in contact with or subject to splashing of brine solution shall be fabricated from red brass or bronze or polyvinyl chloride.

2.3.2 Hydraulic System

A hydraulic ejector or motor-driven centrifugal pump of all bronze construction with valves, piping, and connections shall be provided for lifting brine from the brine or combined tank. Ejector and motor-driven pump shall have sufficient capacity to permit a 2 to 1 variation in the concentrated brine rate of flow. Hydraulic ejector system shall be equipped with a manual rate-set valve and a check valve on the suction side of the ejector. Where the brine tank or combination tank is emptied during each regeneration period, the suction side of the ejector system shall be provided with a device to prevent the entrance of air into the system. Hydraulic ejector system shall be capable of automatically flushing out the dilute brine piping system or completion of the brine cycle. Hydraulic pumping system shall be equipped with a manual rate-set valve, a check valve, and a brine measuring meter on the discharge of the pump. Brine measuring meter shall be electrically interlocked with the pump starter so that after the discharge of a set quantity of brine, the pump motor shall shut down. Set point shall be infinitely adjustable over a 2 to 1 range. Dilution water shall be mixed with the concentrated brine through use of a mixing tee. Water inflow to the mixing tee shall be controlled by means of a manual rate-set valve. System shall be capable of automatically flushing out the dilute brine piping system on completion of the brine regeneration cycle. The dilution water supply shall be protected from inflow of brine by means of back flow prevention device.

2.4 CONTROLS

2.4.1 Valves

Transfer of water and brine solution to and from the water softener shall be accomplished by a single-unit multiple-port valve or by a package-type valve nest for automatic, semiautomatic or manual operation. Design of the valve mechanisms shall be such that gradually increasing flows will be attained as ports are opened and initial surges and sudden inrushes of water or brine are avoided. A dial pointer shall indicate each step of the operation.

2.4.1.1 Multiple-Port Valve

Multiple-port valve shall consist of an assembly of nonsticking, nonleaking, water-lubricated valve ports that connect to the hard-water inlet, soft-water outlet, backwash inlet and outlet, and brine inlet, all enclosed in a single casing. Design shall permit the various steps of operation service, backwash, brine flow, and rinse to be accomplished by the rotation of a shaft that drives the mechanism causing the opening and closing of ports in correct sequence.

2.4.1.2 Package-Type Valve

Package-type valve nest shall consist of a pilot valve connected with fittings as may be required to each one of a nest of valves hydraulically or pneumatically operated. Nest of valves shall have connections to hard-water inlet, soft-water outlet, backwash inlet and outlet, and brine inlet.

2.4.2 Operation

Control of softener regeneration shall be fully automatic initiated by a control switch, semiautomatic initiated manually by a pushbutton in response to an alarm with switch, or manual with operation initiated manually in response to an alarm with switch connected to a water meter or an automatic hardness tester. Use of fully automatic or semiautomatic controls shall permit regeneration to proceed automatically with no manual assistance other than replenishment of salt storage. Controls shall be subject to convenient and accurate manual adjustment and shall be designed for manual operation in the event of failure of the electrical equipment. An interlocking system shall be provided to prevent regeneration of more than one unit at a time.

2.5 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motors or motor starters and controls. Motor starters shall be provided complete with properly sized thermal overload protection and other appurtenances necessary for the motor specified. Electrical work shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices, shall be provided.

2.6 BOLTS, NUTS, AND FASTENERS

All bolts, anchor bolts, nuts, washers, plates, bolt sleeves, and all other types of supports necessary for the installation of the equipment shall be furnished with the equipment and shall be galvanized unless otherwise indicated. Expansion bolts shall have malleable-iron and lead composition elements. Unless otherwise specified, stud, tap, and machine bolts shall be of refined bar iron. All threads shall conform to ASME B1.1. Bolts, anchor bolts, nuts, and washers specified to be galvanized, shall be zinc coated, after being threaded, by the hot-dip process in conformity with ASTM A123/A123M or ASTM A153/A153M. Bolts, anchor bolts, nuts, and washers specified to be stainless steel shall be Type 316 stainless steel. Where indicated, specified, or required, anchor bolts shall be provided with square plates at least 101.6 by 101.6 by 9.5 mm (4 by 4 by 3/8 inch) or shall have square heads and washers and be set in the concrete forms with suitable pipe sleeves.

2.7 AUXILIARY EQUIPMENT

2.7.1 Water Meter

Each softener shall be provided with a displacement or turbine-type water meter reading in U.S. gallons, and shall conform to AWWA C700 or AWWA C701 as appropriate. Meter shall be equipped with necessary wiring and electric controls for automatic regeneration. Meter shall be equipped with necessary wiring and an alarm device to give notice. Meter shall be installed in the soft-water line from the softener unit, and shall be so located as to be readily accessible for reading and setting. Meter contacts shall be infinitely adjustable over the range of the meter to permit setting to suit actual hardness of the water being treated.

2.7.2 Automatic Hardness Tester

A hardness tester for automatically testing the hardness of the water shall be installed in the soft-water line leading from each softener unit. Automatic hardness tester shall be wall mounted and shall be capable of carrying out intermittent tests on the softened water and of giving visual warning that the residual hardness present exceeds a predetermined limit.

2.7.3 Electric Motors

Motors shall be single-phase, suitable for operation on 115-volt, single-phase, 60 cycle, alternating current conforming to NEMA MG 1. Each motor shall be designed for operation in a 40-degree C ambient temperature. Motor controls shall conform to NEMA ICS 1.

2.7.4 Piping

Pipe smaller than 100 mm (4 inches) in diameter, excluding the underdrain and brine collection systems, shall be fabricated from galvanized steel conforming to ASTM A53/A53M with malleable-iron fittings conforming to ASME B16.3. Pipe 100 mm (4 inches) in diameter and larger shall be flanged ductile-iron conforming to AWWA C115/A21.15 with ductile-iron fittings conforming to AWWA C110/A21.10 and AWWA C111/A21.11. Pipe hangers and supports conforming to MSS SP-58 shall be used on all 40 mm (1-1/2 inch) diameter or smaller pipe with runs longer than 2.14 m (7 feet), and on all 50 mm (2 inch) diameter or larger pipe with runs longer than 2.74 m (9 feet). The pipe hanger and supports shall be fabricated from steel and shall be spaced not more than 2.14 to 2.74 m (7 to 9 feet) as applicable.

2.7.5 Valves and Unions

Gate valves smaller than 100 mm (4 inches) shall be bronze with screwed ends, conforming to MSS SP-80 and valves 100 mm (4 inches) or larger shall be iron body with flanged ends, conforming to MSS SP-70. Valves shall open counterclockwise, and the operating wheel shall have an arrow, cast in the metal, indicating the direction of opening. Unions shall conform to ASME B16.39.

2.7.6 Gauges and Cocks

Pressure gauges and sampling cocks shall be furnished on each softener unit connected to the hard-water inlet and soft-water outlet to indicate the pressure loss through the softener and its pipe, valve, and fitting assembly, and to sample the hard and soft water. A sampling cock shall also be provided on the brine system which will permit sampling of the dilute brine solution. Gauges shall be precision type with bronze Bourdon tube and phenolic case and an accuracy of plus or minus 1/2 percent conforming to ASME B40.100. Sampling cocks shall be of brass, ground key, lever handle, faucet type.

2.7.7 Water and Brine Testing Equipment

A complete water-testing set recommended by the manufacturer shall be provided with the softener. The set shall include complete instructions for conducting tests for hardness in accordance with AWWA 10084. Two Baume hydrometers conforming to ASTM E100 and ASTM E126, and calibrated for the range necessary for testing saturated brine solution and three glass cylinders of heat-resistant glass to hold sufficient brine for testing shall also be provided.

2.8 FACTORY PAINTING

Factory painting shall conform to manufacturer's standard factory finish for the intended service.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Submit drawings showing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

3.2.1 Softener and Brine Tanks

Softener and brine tanks shall be anchored to a concrete mat. Anchor brackets, anchor rods or straps shall be provided to hold the tank to the anchors in the mat. Where concrete or gravel fill is provided for support of the header-lateral-distributor head, strainer heads and strainers shall be protected while concrete or gravel fill is being placed.

3.2.2 Valves

Install valves as nearly as possible in the position indicated consistent with convenience of operating the hand wheel. Carefully erect and support all valves in their respective position free from all distortion and strain on appurtenances during handling and installation. All material shall be carefully inspected for defects in workmanship and material, and debris and foreign material cleaned out of valve openings and seats, all operating mechanisms operated to check their proper functioning, and all nuts and bolts checked for tightness. Valves and other equipment which do not operate easily or are otherwise defective shall be repaired or replaced.

3.2.3 Pumps

Pump and motor shall be mounted on a common monoblock. The monoblock shall be anchored to a concrete mat. Anchor brackets, anchor rods, or straps shall be provided to hold the monoblock to the anchors in the mat.

3.2.4 Piping

Install piping to accurate lines and grades and, where possible, parallel to building walls. Where temporary supports are used, they shall be sufficiently rigid to prevent shifting or distortion of the pipe. Provision shall be made for expansion where necessary. All piping shall pitch toward low points, and provision shall be made for draining these low points. A sufficient number of unions or flanges shall be used to allow for the dismantling of all water pipe, valves, and equipment.

Installation of piping including cleaning, cutting, threading and jointing, shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.3 MANUFACTURER'S SERVICES

3.3.1 Manufacturer's Representative

Provide services by a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. Representative shall supervise the installing, adjusting, and testing of equipment.

3.3.2 Field Training

Conduct training course for operating staff as designated by the Contracting Officer. The training period, for a total of 8 hours of normal working time, shall start after the system is functionally completed but prior to final acceptance tests. Submit proposed diagrams, field instructions, and other sheets, prior to posting. Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems. The field instructions shall cover all of the items contained in the Operating and Maintenance Instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operation features. Submit one hard copy and one digital copy (.pdf - text searchable) of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions shall include simplified wiring, layout, and control diagrams of the system as installed.

3.4 TESTING AND PERFORMANCE

After installation of the water softener, operating tests shall be carried out to assure that the water softener system operates properly. If any deficiencies are revealed during any tests, such deficiencies shall be corrected and the tests reperformed.

3.4.1 Softeners

Run each softener to exhaustion and regenerate it to full capacity in accordance with manufacturer's instructions before test is started. Softener shall be put through a complete cycle of operation at a constant flow rate in accordance with manufacturer's recommendations. During capacity test, the softened water shall be wasted to the sewer if necessary to maintain the required flow rate. Total grains of equivalent calcium carbonate removed shall be determined by test of the hard water at such intervals as will give a representative calcium carbonate content.

a. After each run, the unit shall be regenerated using salt brine delivered from the measuring tank in the amount called for by operating instructions. Near the end of the brine rinse and beginning of production of zero soft-water, samples of the water shall be taken every 2.5 minutes, the meter read, and the reading recorded. Samples shall be titrated for chlorides, and zero soft-water production shall be considered to begin when chlorides, as chloride radicals, are not in excess of 20 milligrams per liter above the chloride content of the hard-water. When the required number of liters (gallons) of hard water of specified hardness have been run through the softener, a quart sample shall be taken of the softened water and tested.

b. Results of the test shall be used in determining the capacity and performance of the softener. A sample of hard-water shall be taken and tested in a similar manner. A complete log of each test run shall be made, giving the following data: date, time or readings, total water softened, and pounds of salt used per regeneration. All samples shall be collected in clean, glass-stoppered bottles. Bottles shall be thoroughly rinsed with water being sampled, and all samples shall be plainly marked for identification.

c. Supply the salt required for regeneration of the exchange material after each of the above test runs. Under actual operating conditions the exchange material shall not be washed out of the apparatus, the turbidity and color of the soft water shall not exceed the turbidity and color of the hard water, and during any softening run, slugs of dirty or turbid water shall not be delivered regardless of the change of demand rate up to the maximum on the apparatus. During the specified test of the softener, the soft-water sampling cock shall remain open and a stream of softened water shall be run through a rubber hose, discharging at the bottom of a wide mouth, 3 liter (1 gallon) glass jar or bottle set against a white background so that the color and turbidity may be under observation at all times.

3.4.2 Piping

After installation, test all pipelines for water-tightness. For these tests furnish testing plugs or caps, all necessary pressure pumps, pipe connections, gauges, other equipment, and all labor required. Test pressures shall be indicated in the process pipe schedule shown. Test of joints of air lines shall be made using a soapy water solution to detect leaks. The obtaining of water, electric power and other utility items as well as the disposal of water drainage are also the responsibilities of Contractor. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.5 FIELD PAINTING

Equipment which did not receive a factory finish shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Factory painted items requiring touching up in the field shall be thoroughly cleaned of all foreign material and shall be primed and top-coated with the manufacturer's standard factory finish.

-- End of Section --

SECTION 23 00 00

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.51	(2012) Acoustics Determination of Sound Power Levels of Noise Sources using Sound Pressure Precision Method for Reverberation Rooms

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4	(2001) Installation Techniques for Perimeter Heating and Cooling; 11th Edition

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2007) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 220	(2005) Test Methods for Air Curtain Units
AMCA 300	(2008) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 260 I-P	(2012) Sound Rating of Ducted Air Moving and Conditioning Equipment
AHRI 350	(2008) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units

AHRI 440	(2008) Room Fan-Coils and Unit Ventilators
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AHRI 885	(2008; Addendum 2011) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
AHRI DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; ERTA 2012; S 2013) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 52.2	(2012; Errata 2013; INT 1 2014) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2010; Errata 2011; INT 3 2012; INT 4 2012; INT 5 2013) Ventilation for Acceptable Indoor Air Quality
ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
ASHRAE 70	(2006; R 2011) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 84	(2013; Addenda A 2013) Method of Testing Air-to-Air Heat Exchangers
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013; Errata 1-3 2013; Errata 4-6 2014; Errata 7 2015) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A924/A924M	(2014) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2013) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B280	(2013) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B766	(1986; R 2008) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C1071	(2012) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C916	(2014) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3359	(2009; E 2010; R 2010) Measuring Adhesion by Tape Test
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E2016	(2011) Standard Specification for Industrial Woven Wire Cloth
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1040	(1987; R 2007) Standard Specification for Filter Units, Air Conditioning, Viscous - Impingement and Dry Types, Replaceable

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

IEST RP-CC-001	(2009) HEPA and ULPA Filters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2014) Motors and Generators
NEMA MG 10	(2013) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 701	(2010) Standard Methods of Fire Tests for

	Flame Propagation of Textiles and Films
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 96	(2014) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition
SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition
SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition
SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 4-010-01	(2012) DoD Minimum Antiterrorism Standards for Buildings

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013) Factory-Made Air Ducts and Air Connectors
UL 1995	(2011) Heating and Cooling Equipment
UL 555	(2006; Reprint May 2014) Standard for Fire Dampers
UL 586	(2009; Reprint Sep 2014) Standard for High-Efficiency Particulate, Air Filter Units
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 705	(2004; Reprint Dec 2013) Standard for Power Ventilators
UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building

Materials

UL 900	(2004; Reprint Feb 2012) Standard for Air Filter Units
UL 94	(2013; Reprint Sep 2014) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL Bld Mat Dir	(2012) Building Materials Directory
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2012) Fire Resistance Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3705	(2008) Hot rolled stainless steel plates, sheets and strip

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams shall be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

1.2.1.2 Diagrams

Submit proposed diagrams, at least 2 weeks prior to start of related testing. provide neat mechanical drawings provided with extruded aluminum frame under 3 mm (1/8-inch) glass or laminated plastic, system diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system. After approval, post these items where directed.

1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent installation. Labels shall be in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU - 01
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - 01
VAV Box Number	VAV - 01
Fan Coil Unit Number	FC - 01
Terminal Box Number	TB - 01
Unit Ventilator Number	UV - 01

Identify similar services with different temperatures or pressures. Where pressures could exceed 860 kilopascal (125 pounds per square inch, gage), include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

a. Each point of entry and exit of pipe passing through walls.

b. Each change in direction, i.e., elbows, tees.

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.

d. In long straight runs, locate labels at distances within eyesight of each other not to exceed 22 meter (75 feet). All labels shall be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes	
for Outside Diameters of	Lettering
13 thru 35 mm (1/2 thru 1-3/8 inch)	13 mm (1/2 inch)
40 thru 60 mm (1-1/2 thru 2-3/8 inch)	20 mm (3/4 inch(
65 mm and larger (2-1/2 inch and larger)	32 mm (1-1/4 inch)

1.2.3 Color Coding

Color coding of all piping systems shall be in accordance with ASME A13.1.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office

that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Metallic Flexible Duct
Insulated Nonmetallic Flexible Duct Runouts
Duct Connectors
Duct Access Doors; G
Fire Dampers
Manual Balancing Dampers; G
Sound Attenuation Equipment
Acoustical Duct Liner
Diffusers
Perforated Plate Diffusers
Linear Diffusers
Security Ceiling Diffusers
Registers and Grilles
Louvers
Air Vents, Penthouses, and Goosenecks
Centrifugal Fans; G
In-Line Centrifugal Fans; G
Axial Flow Fans; G
Panel Type Power Wall Ventilators; G
Centrifugal Type Power Wall Ventilators; G
Centrifugal Type Power Roof Ventilators; G
Propeller Type Power Roof Ventilators; G
Air-Curtain Fans; G
Ceiling Exhaust Fans; G
Air Handling Units; G
Room Fan-Coil Units; G
Coil Induction Units; G
Constant Volume, Single Duct Terminal Units; G
Variable Volume, Single Duct Terminal Units; G
Variable Volume, Single Duct, Fan-Powered Terminal Units; G
Dual Duct Terminal Units; G
Ceiling Induction Terminal Units; G
Reheat Units; G
Unit Ventilators; G
Energy Recovery Devices; G
Test Procedures
Diagrams

SD-06 Test Reports

Performance Tests
Damper Acceptance Test

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions
Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL Bld Mat Dir, and UL 6 is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.

b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.

c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Manufacturer shall provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials shall be hot-dip galvanized in accordance with ASTM A123/A123M for exterior locations and cadmium-plated in conformance with ASTM B766 for interior locations.

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Used as Refrigerants

Minimize releases of Ozone Depleting Substances (ODS) during repair, maintenance, servicing or disposal of appliances containing ODS's by complying with all applicable sections of 40 CFR 82 Part 82 Subpart F. Any person conducting repair, maintenance, servicing or disposal of appliances owned by NASA shall comply with the following:

a. Do not knowingly vent or otherwise release into the environment, Class I or Class II substances used as a refrigerant.

b. Do not open appliances without meeting the requirements of 40 CFR 82

Part 82.156 Subpart F, regarding required practices for evacuation and collection of refrigerant, and 40 CFR 82 Part 82.158 Subpart F, regarding standards of recycling and recovery equipment.

c. Only persons who comply with 40 CFR 82 Part 82.161 Subpart F, regarding technician certification, can conduct work on appliances containing refrigerant.

In addition, provide copies of all applicable certifications to the Contracting Officer at least 14 calendar days prior to initiating maintenance, repair, servicing, dismantling or disposal of appliances, including:

a. Proof of Technician Certification

b. Proof of Equipment Certification for recovery or recycling equipment.

c. Proof of availability of certified recovery or recycling equipment.

1.4.4 Use of Ozone Depleting Substances, Other than Refrigerants

The use of Class I or Class II ODS's listed as nonessential in 40 CFR 82 Part 82.66 Subpart C is prohibited. These prohibited materials and uses include:

a. Any plastic party spray streamer or noise horn which is propelled by a chlorofluorocarbon

b. Any cleaning fluid for electronic and photographic equipment which contains a chlorofluorocarbon; including liquid packaging, solvent wipes, solvent sprays, and gas sprays.

c. Any plastic flexible or packaging foam product which is manufactured with or contains a chlorofluorocarbon, including, open cell foam, open cell rigid polyurethane poured foam, closed cell extruded polystyrene sheet foam, closed cell polyethylene foam and closed cell polypropylene foam except for flexible or packaging foam used in coaxial cabling.

d. Any aerosol product or other pressurized dispenser which contains a chlorofluorocarbon, except for those listed in 40 CFR 82 Part 82.66 Subpart C.

Request a waiver if a facility requirement dictates that a prohibited material is necessary to achieve project goals. Submit the waiver request in writing to the Contracting Officer. The waiver will be evaluated and disposition will be provided to Contractor.

1.4.5 Detail Drawings

Submit detail drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.6 Test Procedures

Submit proposed test procedures and test schedules for the ductwork leak test, and performance tests of systems, at least 2 weeks prior to the start of related testing.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Provide equipment items that are supported by a service organization. Where applicable, provide equipment that is an ENERGY STAR Qualified product or a Federal Energy Management Program (FEMP) designated product.

2.2 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Identification plates shall be three layers, black-white-black, engraved to show white letters on black background. Letters shall be upper case. Identification plates 40 mm (1-1/2-inches) high and smaller shall be 1.6 mm (1/16-inch) thick, with engraved lettering 3 mm (1/8-inch) high; identification plates larger than 40 mm (1-1/2-inches) high shall be 3 mm (1/8-inch) thick, with engraved lettering of suitable height. Identification plates 40 mm (1-1/2-inches) high and larger shall have beveled edges. Install identification plates using a compatible adhesive.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard. The requirements for catwalks, operating platforms, ladders, and guardrails are specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

2.4 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system , and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors.

2.5 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts shall not degrade the surrounding concrete.

2.6 SEISMIC ANCHORAGE

Anchor equipment in accordance with applicable seismic criteria for the area and as defined in SMACNA 1981

2.7 PAINTING

Paint equipment units in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouch only if approved. Otherwise, return equipment to the factory for refinishing.

2.8 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.9 DUCT SYSTEMS

2.9.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification .

a. Ductwork shall be constructed and meet requirements for duct system static pressure specified in APPENDIX D of Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

b. Provide radius type elbows with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes are allowed.

c. Provide ductwork that meets the requirements of Seal Class A or C. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.

d. Provide sealants that conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and are suitable for the range of air distribution and ambient temperatures to which it is exposed. Do not use pressure sensitive tape as a sealant.

e. Make spiral lock seam duct, and flat oval with duct sealant and lock with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 50 mm (2 inch) band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.9.1.1 Metallic Flexible Duct

a. Provide duct that conforms to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 497 Pa (2 inches water gauge positive) and 373 Pa (1.5 inches water gauge negative). Provide flexible round duct length that does not exceed 1525 mm (5 feet). Secure connections by applying adhesive for 51 mm (2 inches) over rigid duct, apply flexible duct 51 mm (2 inches) over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Provide interlocking spiral or helically corrugated flexible core constructed of zinc-coated steel, aluminum, or stainless steel; or constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.

c. Insulation: Provide inner duct core that is insulated with mineral fiber blanket type flexible insulation, minimum of 25 mm (1 inch) thick. Provide insulation covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.9.1.2 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length is indicated on the drawings, and is not to exceed 1.5 m (5 feet). Provide runouts that are preinsulated, factory fabricated, and that comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 0.60 L (20 ounce) glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. Provide a die-stamped elbow and not a flexible connector as the last elbow to these units other than the vertical air inlet type. Insulated flexible connectors are allowed as runouts. Provide insulated material and vapor barrier that conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Do not expose the insulation material surface to the air stream.

2.9.1.3 General Service Duct Connectors

Provide a flexible duct connector approximately 150 mm (6 inches) in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardant fabrics" in UL Bld Mat Dir.

2.9.1.4 High Temperature Service Duct Connections

Provide material that is approximately 2.38 mm (3/32 inc)h thick, 1.2 to 1.36 kg per square meter (35 to 40-ounce per square yard) weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 650 degrees C (1200 degrees F).

2.9.1.5 Aluminum Ducts

ASTM B209M (ASTM B209), alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.9.1.6 Copper Sheets

ASTM B152/B152M, light cold rolled temper.

2.9.1.7 Corrosion Resisting (Stainless) Steel Sheets

ASTM A167 or KS D 3705

2.9.2 Duct Access Doors

Provide hinged access doors conforming to SMACNA 1966 in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum 375 by 450 mm (15 by 18 inches), unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable. Equip doors 600 by 600 mm (24 by 24 inches) or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.9.3 Fire Dampers

Use 1.5 hour rated fire dampers unless otherwise indicated. Provide fire dampers that conform to the requirements of NFPA 90A and UL 555. Perform the fire damper test as outlined in NFPA 90A. Provide a pressure relief door upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then provide a factory installed pressure relief damper. Provide automatic operating fire dampers with a dynamic rating suitable for the maximum air velocity and pressure differential to which it is subjected. Provide fire dampers approved for the specific application, and install according to their listing. Equip fire dampers with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, does not impair the operation of the damper. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with UL Fire Resistance. Provide curtain type, single or multi-blade fire dampers, in or out of the air stream as indicated. Install dampers that do not reduce the duct or the air transfer opening cross-sectional area. Install dampers so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, comply with the installation details given in SMACNA 1819 and in manufacturer's instructions for fire dampers. Perform acceptance testing of fire dampers according to paragraph Fire Damper Acceptance Test and NFPA 90A.

2.9.4 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multi-leaf dampers with maximum blade width of 300 mm (12 inches). Provide access doors or panels for all concealed damper operators and locking setscrews. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

2.9.5 Air Supply And Exhaust Air Dampers

Where outdoor air supply and exhaust air dampers are required they shall have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - SI (ASHRAE 90.1 - IP) or UFC 4-010-01, including maximum Damper Leakage for:

a. Climate Zones 1,2,6,7,8 the maximum damper leakage at 250 Pa (1.0 inch w.g.) for motorized dampers is 20 L/s per square m (4 cfm per square foot) of damper area and non-motorized dampers are not allowed.

b. All other Climate Zones the maximum damper leakage at 250 Pa (1.0 inch w.g.) is 50 L/s per square m (10 cfm per square foot) and for non-motorized dampers is 100 L/s per square m (20 cfm per square foot) of damper area.

Dampers smaller than 600 mm (24 inches) in either direction may have leakage of 200 L/s per square m (40 cfm per square foot).

2.9.6 Air Deflectors and Branch Connections

Provide air deflectors at all duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections are allowed in lieu of deflectors for branch connections. Furnish all air deflectors, except those installed in 90 degree elbows, with an approved means of adjustment. Provide easily accessible means for adjustment inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, provide external adjustments with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Provide factory-fabricated air deflectors consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Provide factory or field assembled air deflectors. Make adjustment from the face of the diffuser or by position adjustment and lock external to the duct. Provide stand-off brackets on insulated ducts as described herein. Provide fixed air deflectors, also called turning vanes, in 90 degree elbows.

2.9.7 Plenums and Casings for Field-Fabricated Units

2.9.7.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA 1966, as applicable. Construct system casing of not less than 1.6 mm (16 gauge) galvanized sheet steel. Furnish cooling coil drain pans with 25 mm (1 inch) threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 1.6 mm (16 gauge) steel, galvanized after fabrication or of 1.3 mm (18 gauge) corrosion-resisting sheet steel conforming to ASTM A167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Coat insulation with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 500 Pa (2 inch water gauge) greater than the maximum negative pressure in the coil space.

2.9.7.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA 1966.

2.9.7.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, make doors 900 by 450 mm (36 by 18 inches) and locate them 450 mm (18 inches) above the floor. Where the space available does not accommodate doors of this size, use doors as large as the space accommodates. Swing doors so that fan suction or pressure holds doors in closed position, airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.9.7.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components are allowed for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Provide panels of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Seal and insulate panel joints. Provide and gasket access doors to prevent air leakage. Provide panel construction that is not less than one mm (20 gauge) galvanized sheet steel, assembled with fasteners treated against corrosion. Provide standard length panels that deflect not more than 13 mm (1/2 inch) under operation. Construct details, including joint sealing, not specifically covered, as indicated in SMACNA 1966. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.9.7.5 Duct Liner

Unless otherwise specified, duct liner is not permitted.

2.9.8 Sound Attenuation Equipment

a. For systems with total pressure above 1 kPa (4 Inches Water Gauge): Provide sound attenuators on the discharge duct of each fan operating at a total pressure above 1 kPa (4 inch water gauge), and, when indicated, at the intake of each fan system. Provide sound attenuators elsewhere as indicated. Provide factory fabricated sound attenuators, tested by an independent laboratory for sound and performance characteristics. Provide a net sound reduction as indicated. Maximum permissible pressure drop is not to exceed 157 Pa (0.63 inch water gauge). Construct traps to be airtight when operating under an internal static pressure of 2.5 kPa (10 inch water gauge). Provide air-side surface capable of withstanding air velocity of 50 m/s (10,000 fpm). Certify that the equipment can obtain the sound reduction values specified after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Provide sound absorbing material conforming to

ASTM C1071, Type I or II. Provide sound absorbing material that meets the fire hazard rating requirements for insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For connection to ductwork, provide a duct transition section. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system can be provided if complying with requirements specified for factory fabricated sound attenuators, in lieu of factory fabricated sound attenuators. Construct the double-walled duct and fittings from an outer metal pressure shell of zinc-coated steel sheet, 25 mm (1 inch) thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Provide a sufficient length of run to obtain the noise reduction coefficient specified. Certify that the sound reduction value specified can be obtained within the length of duct run provided. Provide welded or spiral lock seams on the outer sheet metal of the double-walled duct to prevent water vapor penetration. Provide duct and fittings with an outer sheet that conforms to the metal thickness of high-pressure spiral and round ducts and fittings shown in SMACNA 1966. Provide acoustical insulation with a thermal conductivity "k" of not more than 0.0389 W/m-K (0.27 Btu/inch/square foot/hour/degree F) at 24 degrees C (75 degrees F) mean temperature. Provide an internal perforated zinc-coated metal liner that is not less than 0.7 mm (24 gauge) with perforations not larger than 6.35 mm (1/4 inch) in diameter providing a net open area not less than 10 percent of the surface.

b. For system with total pressure of 1 kPa (4 Inch Water Gauge(and Lower: Use sound attenuators only where indicated. Provide factory fabricated sound attenuators that are constructed of galvanized steel sheets. Provide attenuator with outer casing that is not less than 0.85 mm (22 gauge). Provide fibrous glass acoustical fill. Provide net sound reduction indicated. Obtain values on a test unit not less than 600 by 600 mm (24 by 24 inches) outside dimensions made by a certified nationally recognized independent acoustical laboratory. Provide air flow capacity as indicated or required. Provide pressure drop through the attenuator that does not exceed the value indicated, or that is not in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Acoustically test attenuators with metal duct inlet and outlet sections while under the rated air flow conditions. Include with the noise reduction data the effects of flanking paths and vibration transmission. Construct sound attenuators to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 500 Pa (2 inch water gauge).

c. For acoustical duct liner: Use fibrous glass designed or flexible elastomeric duct liner for lining ductwork and conforming to the requirements of ASTM C1071, Type I and II. Provide uniform density, graduated density, or dual density liner composition, as standard with the manufacturer. Provide not less than 25 mm (1 inch) thick coated lining. Where acoustical duct liner is used, provide the thermal equivalent of the insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS for liner or combination of liner and insulation applied to the exterior of the ductwork. Increase duct sizes shown to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, provide acoustically equivalent lengths of fibrous glass duct, elastomeric duct liner or factory fabricated double-walled internally insulated duct with perforated liner.

2.9.9 Diffusers, Registers, and Grilles

Provide factory-fabricated units of corrosion-resistant steel or aluminum that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m (7 feet) above the floor, protect them by a grille or screen according to NFPA 90A.

2.9.9.1 Diffusers

Provide diffuser types indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Constructn for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units that are similar to supply diffusers.

2.9.9.2 Perforated Plate Diffusers

Provide adjustable one-way, two-way, three-way, or four-way air pattern controls as indicated. Provide diffuser faceplates that do not sag or deflect when operating under design conditions.

2.9.9.3 Linear Diffusers

Make joints between diffuser sections that appear as hairline cracks. Provide alignment slots for insertion of key strips or other concealed means to align exposed butt edges of diffusers. Equip with plaster frames when mounted in plaster ceiling. Do not use screws and bolts in exposed face of frames or flanges. Metal-fill and ground smooth frames and flanges exposed below ceiling. Furnish separate pivoted or hinged adjustable air-volume-damper and separate air-deflection blades.

2.9.9.4 Security Ceiling Diffusers

Provide diffusers that are steel with faceplate, fixed diffusion louvers, with flat surface margin, and an opposed blade damper. Provide faceplate that is 1.9 mm (14 gage) minimum with 13 by 13 mm holes on 5 mm (1/2 by 1/2 inch holes on 3/16 inch) spacing and a minimum free area of 45 percent.

2.9.9.5 Registers and Grilles

Provide units that are four-way directional-control type, except provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 150 mm (6 inches) below the ceiling unless otherwise indicated. Locate return and exhaust registers 150 mm (6 inches) above the floor unless otherwise indicated. Achieve four-way directional control by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Provide grilles as specified for registers, without volume control damper.

2.9.10 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Sections 07 60 00 FLASHING AND SHEET METAL and 08 91 00 METAL WALL AND DOOR LOUVERS.

2.9.11 Air Vents, Penthouses, and Goosenecks

Fabricate air vents, penthouses, and goosenecks from galvanized steel or aluminum sheets with galvanized or aluminum structural shapes. Provide sheet metal thickness, reinforcement, and fabrication that conform to SMACNA 1966. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.9.12 Bird Screens and Frames

Provide bird screens that conform to ASTM E2016, No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.9.13 Radon Exhaust Ductwork

Fabricate radon exhaust ductwork installed in or beneath slabs from Schedule 40 PVC pipe that conforms to ASTM D1785. Provide fittings that conform to ASTM D2466. Use solvent cement conforming to ASTM D2564 to make joints. Otherwise provide metal radon exhaust ductwork as specified herein.

2.10 AIR SYSTEMS EQUIPMENT

2.10.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans shall not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than 150 percent of the connected driving capacity. Provide variable pitch motor sheaves for 11 kW (15 hp) and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.10.1.1 Centrifugal Fans

Provide fully enclosed, single-width single-inlet, or double-width double-inlet centrifugal fans, with AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Provide impeller wheels that are rigidly constructed and accurately balanced both statically and dynamically. Provide forward curved or backward-inclined airfoil design fan blades in wheel sizes up to 750 mm (30 inches). Provide backward-inclined airfoil design fan blades for wheels over 750 mm (30 inches) in diameter. Provide open-wheel radial type booster fans for exhaust dryer systems, and fans suitable for conveying lint and the temperatures encountered. Equip the fan shaft with a heat slinger to dissipate heat buildup along the shaft. Install an access (service) door to facilitate maintenance of these fans. Provide fan wheels over 900 mm (36 inches) in diameter with overhung pulleys and a bearing on each side of the wheel. Provide fan wheels 900 mm (36 inches) or less in diameter that have one or more extra long bearings between the fan wheel and the drive. Provide sleeve type, self-aligning and self-oiling bearings with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Connect grease fittings to tubing for serviceability from a single accessible point. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide steel, accurately finished fan shafts, with key seats and keys for impeller hubs and fan pulleys. Provide fan outlets of ample proportions, designed for the attachment of angles and bolts for attaching flexible connections. Providemanually or automatically operated inlet vanes on suction inlets. Provide manually or automatically operated outlet dampers. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have open , drip proof , totally enclosed , or explosion-proof enclosures as indicated. Provide manual or magnetic, across-the-line or reduced-voltage-start type motor starters with general-purpose, weather-resistant, or watertight enclosure as indicated. Provide remote manual switch with pilot indicating light where indicated.

2.10.1.2 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide motors with open, drip proof, totally enclosed, or explosion-proof enclosure as indicated. Provide manual or magnetic motor starters across-the-line with general-purpose, weather-resistant, or explosion-proof enclosures as indicated. Provide remote manual switch with pilot indicating light where indicated.

2.10.1.3 Axial Flow Fans

Provide axial flow fans complete with drive components and belt guard, with steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Provide fan wheels that are dynamically balanced and keyed to the fan shaft, with radially projecting blades of airfoil cross-section. Enclose and isolate fan bearings and drive shafts from the air stream. Permanently lubricate fan bearings or provide them with accessible grease fittings. Provide precision self-aligning ball or roller type fan bearings that are sealed against dust and dirt. Provide fan bearings that have a L50 rated bearing life at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Provide fan inlets with an aerodynamically shaped bell and an inlet cone. Install diffuser or straightening vanes at the fan discharge to minimize turbulence and provide smooth discharge air flow. Furnish fan unit with inlet and outlet flanges, inlet screen, duct equalizer section, and manual or automatic operation adjustable inlet vanes. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have open, drip proof, totally enclosed, or explosion-proof enclosure as indicated. Provide manual or magnetic motor starters across-the-line with general-purpose, weather-resistant, or explosion-proof enclosure as indicated. Provide remote manual switch with pilot indicating light where indicated.

2.10.1.4 Panel Type Power Wall Ventilators

Provide propeller type fans, assembled on a reinforced metal panel with venturi opening spun into panel. Provide direct or V-belt driven fans with wheels less than 600 mm (24 inches) in diameter and provide V-belt driven fans with wheels 600 mm (24 inches) in diameter and larger. Provide fans with wall mounting collar. Provide lubricated bearings. Equip fans with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Provide drip proof, totally enclosed fan cooled, or explosion-proof type motor enclosure as indicated. Install gravity or motor operated backdraft dampers where indicated.

2.10.1.5 Centrifugal Type Power Wall Ventilators

Provide direct or V-belt driven centrifugal type fans with backward inclined, non-overloading wheel. Provide removable and weatherproof motor housing. Provide unit housing that is designed for sealing to building surface and for discharge and condensate drippage away from building surface. Construct housing of heavy gauge aluminum. Equip unit with an aluminum or plated steel wire discharge bird screen, disconnect switch, anodized aluminum or stainless steel wall grille, manufacturer's standard gravity or motor-operated damper, an airtight and liquid-tight metallic wall sleeve. Provide totally enclosed fan cooled, drip proof, or explosion-proof type motor enclosure as indicated. Use only lubricated bearings.

2.10.1.6 Centrifugal Type Power Roof Ventilators

Provide direct or V-belt driven centrifugal type fans with backward inclined, non-overloading wheel. Provide hinged or removable and weatherproof motor compartment housing, constructed of heavy gauge aluminum. Provide fans with bird screen, disconnect switch, gravity or motorized dampers, sound curb, roof curb, and extended base. Provide drip proof or explosion-proof type motor enclosure. Provide centrifugal type kitchen exhaust fans according to UL 705, fitted with V-belt drive, round hood, and wind band up blast discharge configuration, integral residue trough and collection device, with motor and power transmission components located in outside positively air ventilated compartment. Use only lubricated bearings.

2.10.1.7 Propeller Type Power Roof Ventilators

Provide direct or V-belt driven fans. Provide hinged or removable weathertight fan housing, fitted with framed rectangular base constructed of aluminum or galvanized steel. Provide totally enclosed fan cooled or explosion-proof type motors. Furnish motors with nonfusible, horsepower rated, manual disconnect mount on unit. Furnish fans with gravity or motor operated dampers, bird screen, sound curb, roof curb. Use only lubricated bearings.

2.10.1.8 Air-Curtain Fans

Provide fans that conform to AMCA 220 with AMCA seal. Furnish air curtains with a weatherproof housing constructed of high impact plastic or minimum 1.3 mm (18 gauge) rigid welded steel. Provide backward curved, non-overloading, centrifugal type fan wheels, accurately balanced statically and dynamically. Provide motors with totally enclosed fan cooled enclosures. Provide remote manual type motor starters with weather-resistant enclosure actuated when the doorway served is open. Provide air curtains that attain the air velocities specified within 2 seconds following activation. Provide bird screens at air intake and discharge openings. Provide air curtain unit or a multiple unit installation that is at least as wide as the opening to be protected. Provide the air discharge openings to permit outward adjustment of the discharge air. Place installation and adjust according to the manufacturer's written recommendation. Furnish directional controls on air curtains for service windows for easy clean or convenient removal. Design air curtains to prevent the adjustment of the air velocities specified. Make the interior surfaces of the air curtain units accessible for cleaning. Provide certified test data indicating that the fan can provide the air velocities required when fan is mounted as indicated. Provide air curtains designed as fly fans unless otherwise indicated. Provide air curtains designed for use in service entranceways that develop an air curtain not less than 75 mm (3 inches) thick at the discharge nozzle. Provide air velocity that is not less than 8 m/s (1600 fpm) across the entire entryway when measured 900 mm (3 feet) above the floor. Provide air curtains designed for use on customer entranceways that develop an air curtain not less than 200 mm (8 inches) thick at the discharge opening. Provide velocity that is not less than 3 m/s (600 fpm) across the entire entryway when measured 900 mm (3 feet) above the floor. Equip recirculating type air curtains with readily removable filters, or design the filters for in-position cleaning. Provide readily accessible and easily cleanable air capture compartment or design for in-position cleaning. Provide air curtains designed for use on service windows that develop an air curtain not less than 200 mm (8 inches) thick at the discharge opening. Provide air velocity that is not less than 3 m/s (600 fpm) across the entire opening of the service window measured 900 mm(3 feet) below the air discharge opening.

2.10.1.9 Ceiling Exhaust Fans

Provide centrifugal type, direct driven suspended cabinet-type ceiling exhaust fans. Provide fans with acoustically insulated housing. Provide chatter-proof backdraft damper. Provide egg-crate design or louver design integral face grille. Mount fan motors on vibration isolators. Furnish unit with mounting flange for hanging unit from above. Provide U.L. listed fans.

2.10.2 Coils

Provide fin-and-tube type coils constructed of seamless copper tubes and aluminum or copper fins mechanically bonded or soldered to the tubes. Provide copper tube wall thickness that is a minimum of 0.508 mm (0.020 inches). Provide aluminum fins that are 0.19 mm (0.0075 inch) minimum thickness. Provide copper fins that are 0.114 mm (0.0045 inch) minimum thickness. Provide casing and tube support sheets that are not lighter than 1.6 mm (16 gauge) galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Test each coil at the factory under water at not less than 2.76 MPa (400 psi) air pressure and make suitable for 1.38 MPa (200 psi) working pressure and 149 degrees C (300 degrees F) operating temperature unless otherwise stated. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410.

2.10.2.1 Direct-Expansion Coils

Provide suitable direct-expansion coils for the refrigerant involved. Provide refrigerant piping that conforms to ASTM B280 and clean, dehydrate and seal. Provide seamless copper tubing suction headers or seamless or resistance welded steel tube suction headers with copper connections. Provide supply headers that consist of a distributor which distributes the refrigerant through seamless copper tubing equally to all circuits in the coil. Provide circuited tubes to ensure minimum pressure drop and maximum heat transfer. Provide circuiting that permits refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Provide field installed coils which are completely dehydrated and sealed at the factory upon completion of pressure tests.

2.10.2.2 Water Coils

Install water coils with a pitch of not less than 10 mm/m (1/8 inch/foot) of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans.

2.10.2.3 Steam Heating Coils

Construct steam coils from cast semi-steel, welded steel or copper headers, and copper tubes. Construct headers from cast iron, welded steel or copper. Provide fin tube and header section that float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide each coil with a field or factory installed vacuum breaker. Provide single-tube type coils with tubes not less than 13 mm (1/2 inch) outside diameter, except for steam preheat coils. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent.

2.10.2.4 Steam Preheat (Nonfreeze) Coils

Provide steam-distribution-tube type steam (nonfreeze) coils with condensing tubes not less than 25 mm (1 inch) outside diameter for tube lengths 1.5 m (60 inches) and over and 13 mm (1/2 inch) outside diameter for tube lengths under 1.5 m (60 inches). Construct headers from cast iron, welded steel, or copper. Provide distribution tubes that are not less than 15 mm (5/8 inch) outside diameter for tube lengths 1.5 m (60 inches) and over and 10 mm (3/8 inch) outside diameter for tube lengths under 1.5 m (60 inches) with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes and hold securely in alignment. Limit maximum length of a single coil to 3.66 m (144 inches). Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent.

2.10.3 Air Filters

List air filters according to requirements of UL 900, except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method under the Label Service to meet the requirements of UL 586.

2.10.3.1 Extended Surface Pleated Panel Filters

Provide 50 mm (2 inch) depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2. Provide initial resistance at 2.54 m/s (500 fpm) that does not exceed 0.09 kPa (0.36 inches water gauge). Provide UL Class 2 filters, and non-woven cotton and synthetic fiber mat media. Attach a wire support grid bonded to the media to a moisture resistant fiberboard frame. Bond all four edges of the filter media to the inside of the frame to prevent air bypass and increase rigidity.

2.10.3.2 Extended Surface Unsupported Pocket Filters

Provide 750 mm (30 inch) depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at 2.54 m/s (500 fpm) that does not exceed 0.1125 kPa (0.45 inches water gauge). Provide UL Class 1 filters. Provide fibrous glass media, supported in the air stream by a wire or non-woven synthetic backing and secured to a galvanized steel metal header. Provide pockets that do not sag or flap at anticipated air flows. Install each filter with an extended surface pleated panel filter as a pre-filter in a factory preassembled, side access housing or a factory-made sectional frame bank, as indicated.

2.10.3.3 Cartridge Type Filters

Provide 305 mm (12 inch) depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at 2.54 m/s (500 fpm) that does not exceed 0.14 kPa (0.56 inches, water gauge). Provide UL class 1 filters, and pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow have no effect on filter integrity or performance. Install each filter with an extended surface pleated media panel filter as a pre-filter in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.10.3.4 Sectional Cleanable Filters

Provide 50 mm 2 inch thick cleanable filters. Provide viscous adhesive in 20 L (5 gallon) containers in sufficient quantity for 12 cleaning operations and not less than one L (one quart) for each filter section. Provide one washing and charging tank for every 100 filter sections or fraction thereof; with each washing and charging unit consisting of a tank and single or double drain rack mounted on legs and drain rack with dividers and partitions to properly support the filters in the draining position.

2.10.3.5 Replaceable Media Filters

Provide the dry-media or viscous adhesive type replaceable media filters, of the size required to suit the application. Provide filtering media that is not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Enclose pad in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding 1.5 m/s (300 fpm), with initial resistance of 32 Pa (0.13 inches water gauge).

2.10.3.6 Automatic Renewable Media Filters

Provide the following:

a. Automatic, renewable media filters consisting of a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass supplied in convenient roll form, and filter that does not require water supply, sewer connections, adhesive reservoir, or sprinkler equipment as part of the operation and maintenance requirements.

b. Basic frame that is fabricated of not less than 2 mm (14 gauge) galvanized steel, and sectional design filters with each section of each filter fully factory assembled, requiring no field assembly other than setting in place next to any adjacent sections and the installation of media in roll form.

c. Each filter complete with initial loading of filter media drive motor adequate to handle the number of sections involved, and painted steel or stainless steel control box containing a warning light to indicate media runout, a runout switch, and a Hand-Off-Auto selector switch.

d. Media feed across the filter face in full-face increments or increments automatically controlled as determined by filter pressure differential, time interval control, time interval control with pressure override, or photo electric control to provide substantially constant operating resistance to airflow and varying not more than plus or minus 10 percent. Roll or enclose media in such a way that collected particulates cannot re-entrain.

e. Rolls of clean media, no less than 19.8 m (65 feet) long, rerolled on disposable spools in the rewind section of the filter after the media has accumulated its design dirt load. Equip rewind section with a compression panel to tightly rewind used media for ease of handling. Media shall be of continuous, bonded fibrous glass material, UL Class 2, that does not compress more than 6 mm (1/4 inch) when subjected to air flow at 2.54 m/s (500 fpm). Factory charge media with an odorless and flame retardant adhesive which does not flow while in storage nor when subjected to temperatures up to 79.4 degrees C (175 degrees F). Support media on both the leaving and entering air faces. Clean media shall have initial resistance that does not exceed 45 Pa (0.18 inch water gauge) at its rated velocity of 2.54 m/s (500 fpm). Set control so that the resistance to air flow is between 100 and 125 Pa (0.40-and 0.50 inch water gauge) unless otherwise indicated.

f. Dust holding capacity, of 80 percent average arrestance under these operating conditions, when operating at a steady state with an upper operating resistance of 125 Pa(0.50 inch water gauge), that is at least 592 (55) grams of ASHRAE Standard Test Dust per square meter (foot) of media area, when tested according to the dynamic testing provisions of ASHRAE 52.2.

g. The horizontal type automatic renewable media filters, when used in conjunction with factory fabricated air handling units, that are dimensionally compatible with the connecting air handling units, and horizontal type filter housings with all exposed surfaces factory insulated internally with 25 mm (1 inch), 24 kg/cubic meter (1-1/2 pound) density neoprene coated fibrous glass with thermal conductivity not greater than 0.04 W/m-K (0.27 Btu/hour/degree F/square foot/inch) of thickness.

h. Access doors for horizontal filters with double wall construction as specified for plenums and casings for field-fabricated units in paragraph DUCT SYSTEMS.

2.10.3.7 Electrostatic Filters

Provide the following:

a. The combination dry agglomerator/extended surface, unsupported pocket electrostatic filters or the combination dry agglomerator/automatic renewable, media (roll) type electrostatic filters, as indicated (except as modified). Supply each dry agglomerator electrostatic air filter with the correct quantity of fully housed power packs and equip with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, with lamps mounted in the cover to indicate these functions locally. Equip power pack enclosure with external mounting brackets, and low and high voltage terminals fully exposed with access cover removed for ease of installation. Furnish interlock safety switches for each access door and access panel that permits access to either side of the filter, so that the filter is de-energized in the event that a door or panel is opened.

b. Ozone generation within the filter that does not exceed five parts per one hundred million parts of air. Locate high voltage insulators in a serviceable location outside the moving air stream or on the clean air side of the unit. Fully expose ionizer wire supports and furnish ionizer wires precut to size and with formed loops at each end to facilitate ionizer wire replacement.

c. Agglomerator cell plates that allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up, with cells that are open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, provide a storage section that utilizes a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service supplied in 19.8 m (65 foot) lengths in convenient roll form. Otherwise, provide section construction and roll media characteristics as specified for automatic renewable media filters. Also a dry agglomerator/renewable media combination with an initial air flow resistance, after installation of clean media, that does not exceed 62.3 Pa (0.25 inch water gauge) at 2.54 m/s (500 fpm) face velocity.

d. A MERV of the combination that is not less than 15 when tested according to ASHRAE 52.2 at an average operating resistance of 125 Pa (0.50 inch water gauge). Where the dry agglomerator electrostatic filter is indicated to be of the extended surface unsupported pocket filter type, provide a storage section as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated.

e. A dry agglomerator/extended surface unsupported pocket filter section combination with initial air flow resistance, after installation of clean filters, that does not exceed 162 Pa (0.65 inch water gauge) at 2.54 m/s (500 fpm) face velocity, with a MERV of the combination not less than 16 when tested according to ASHRAE 52.2. Furnish front access filters with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, supply side access housings which have dimensional compatibility.

2.10.3.8 High-Efficiency Particulate Air (HEPA) Filters

Provide HEPA filters that meet the requirements of IEST RP-CC-001 and are individually tested and certified to have an efficiency of not less than 95 percent, and an initial resistance not to exceed the value indicated in the contract drawings and documents. Provide filters that are constructed by pleating a continuous sheet of filter medium into closely spaced pleats separated by corrugated aluminum or mineral-fiber inserts, strips of filter medium, or by honeycomb construction of the pleated filter medium. Provide interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer that are cemented to the perimeter of the upstream or downstream face of the filter cell sides. Provide self-extinguishing rubber-base type adhesive or other materials conforming to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Provide filter cell sides that are 19 mm (3/4 inch) thick exterior grade fire-retardant plywood, cadmium plated steel, or galvanized steel assembled in a rigid manner. Provide overall cell side dimensions that are correct to 2 mm (1/16 inch), and squareness that is maintained to within 3.2 mm (1/8 inch). Provide holding frames that use spring loaded fasteners or other devices to seal the filter tightly within it and that prevent any bypass leakage around the filter during its installed life. Provide air capacity and the nominal depth of the filter as indicated. Install each filter in a factory preassembled side access housing or a factory-made sectional supporting frame as indicated. Provide prefilters of the type, construction and efficiency indicated.

2.10.3.9 Holding Frames

Fabricate frames from not lighter than 1.6 mm (16 gauge) sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Provide gasketed holding frame seats. Make all joints airtight.

2.10.3.10 Filter Gauges

Provide dial type filter gauges, diaphragm actuated draft for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Gauges shall be at least 98 mm (3-7/8 inches) in diameter, with white dials with black figures, and graduated in 0.0025 kPa (0.01 inch of water), with a minimum range of 0.25 kPa (1 inch of water) beyond the specified final resistance for the filter bank on which each gauge is applied. Provide each gauge with a screw operated zero adjustment and two static pressure tips with integral compression fittings, two molded plastic vent valves, two 1.5 m (5 foot) minimum lengths of 6.35 mm (1/4 inch) diameter aluminum or vinyl tubing, and all hardware and accessories for gauge mounting.

2.11 AIR HANDLING UNITS

2.11.1 Field-Fabricated Air Handling Units

Provide built-up units as specified in paragraph DUCT SYSTEMS. Provide fans, coils spray-coil dehumidifiers, and air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

2.11.2 Factory-Fabricated Air Handling Units

Provide single-zone draw-through type, single-zone blow-through type, multizone blow-through type, blow-through double-deck type, or blow-through triple deck type units as indicated. Units shall include fans, coils, airtight insulated casing, prefilters, secondary filter sections, and diffuser sections where indicated, air blender adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, mixing box or combination sectional filter-mixing box, pan, drysteam, or spray type humidifier, vibration-isolators, and appurtenances required for specified operation. Provide vibration isolators as indicated. Physical dimensions of each air handling unit shall be suitable to fit space allotted to the unit with the capacity indicated. Provide air handling unit that is rated in accordance with AHRI 430 and AHRI certified for cooling.

2.11.2.1 Casings

Provide the following:

a. Casing sections single or 50 mm (2 inch) double wall type as indicated, constructed of a minimum 1.3 mm (18 gauge) galvanized steel, or 1.3 mm (18 gauge) corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Inner casing of double-wall units that are a minimum one mm (20 gauge) solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing.

b. Individually removable exterior panels with standard tools. Removal shall not affect the structural integrity of the unit. Furnish casings with access sections, according to paragraph AIR HANDLING UNITS, inspection doors, and access doors, all capable of opening a minimum of 90 degrees, as indicated.

c. Insulated, fully gasketed, double-wall type inspection and access doors, of a minimum 1.3 mm (18 gauge) outer and one mm (20 gauge) inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Doors shall be rigid and provided with heavy duty hinges and latches. Inspection doors shall be a minimum 300 mm (12 inches) wide by 300 mm (12 inches) high. Access doors shall be a minimum 600 mm (24 inches) wide, the full height of the unit casing or a minimum of 1800 mm(6 foot), whichever is less. Install a minimum 200 by 200 mm(8 by 8 inches) sealed glass window suitable for the intended application, in all access doors.

d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 1.4 mm (16 gauge) galvanized steel or corrosion resisting sheet steel conforming to ASTM A167, Type 304, conforming to ASHRAE 62.1. Construct drain pans water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils shall not flow across the face of lower coils. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan to allow for easy visual inspection, including underneath the coil without removal of the coil and to allow complete and easy physical cleaning of the pan underneath the coil without removal of the coil. Coils shall be individually removable from the casing.

e. Casing insulation that conforms to NFPA 90A. Single-wall casing sections handling conditioned air shall be insulated with not less than 25 mm (1 inch) thick, 24 kg/cubic meter (1-1/2 pound) density coated fibrous glass material having a thermal conductivity not greater than 0.033 W/m-K (0.23 Btu/hr-sf-F). Double-wall casing sections handling conditioned air shall be insulated with not less than 50 mm (2 inches(of the same insulation specified for single-wall casings. Foil-faced insulation is not an acceptable substitute for use with double wall casing. Double wall insulation shall be completely sealed by inner and outer panels.

f. Factory applied fibrous glass insulation that conforms to ASTM C1071, except that the minimum thickness and density requirements do not apply, and that meets the requirements of NFPA 90A. Make air handling unit casing insulation uniform over the entire casing. Foil-faced insulation is not an acceptable substitute for use on double-wall access doors and inspections doors and casing sections.

g. Duct liner material, coating, and adhesive that conforms to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or coat to meet erosion resistance requirements of ASTM C1071.

h. A latched and hinged inspection door, in the fan and coil sections. Plus additional inspection doors, access doors and access sections where indicated.

2.11.2.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.11.2.3 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.11.2.4 Fans

Provide the following:

a. Fans that are double-inlet, centrifugal type with each fan in a separate scroll. Dynamically balance fans and shafts prior to installation into air handling unit, then after it has been installed in the air handling unit, statically and dynamically balance the entire fan assembly. Mount fans on steel shafts, accurately ground and finished.

b. Fan bearings that are sealed against dust and dirt and are precision self-aligning ball or roller type, with L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Support bearings by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Do not fasten bearings directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated.

c. Fans that are driven by a unit-mounted, or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Furnish belt guards that are the three-sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than a 1.3 service factor based on motor nameplate rating.

d. Motor sheaves that are variable pitch for 20 kW (25 hp) and below and fixed pitch above 20 kW (25 hp) as defined by AHRI Guideline D. Where fixed sheaves are required, the use of variable pitch sheaves is allowed during air balance, but replace them with an appropriate fixed sheave after air balance is completed. Select variable pitch sheaves to drive the fan at a speed that produces the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives with adjustable bases, and with open, splashproof, or totally enclosed enclosures.

e. Motor starters of manual or magnetic, across-the-line or reduced-voltage-start type with general-purpose, weather-resistant, or watertight enclosure. Select unit fan or fans to produce the required capacity at the fan static pressure with sound power level as indicated. Obtain the sound power level values according to AMCA 300, ASHRAE 68, or AHRI 260 I-P.

2.11.2.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.11.2.6 Diffuser Sections

Furnish diffuser sections between the discharge of all housed supply fans and cooling coils of blow-through single zone units and filter sections of those units with high efficiency filters located immediately downstream of the air handling unit fan section. Provide diffuser sections that are fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, designed to be airtight under positive static pressures up to 2 kPa (8 inches water gauge) and with an access door on each side for inspection purposes. Provide a diffuser section that contains a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish, and designed to accomplish uniform air flow across the down-stream coil and filters while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

2.12 TERMINAL UNITS

2.12.1 Room Fan-Coil Units

Provide base units that include galvanized coil casing, coil assembly drain pan valve and piping package, outside air damper, wall intake box, air filter, fans, motor, fan drive, motor switch, an enclosure for cabinet models and casing for concealed models, leveling devices integral with the unit for vertical type units, and sound power levels as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models are acceptable for concealed models without separate test provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Fasten each unit securely to the building structure. Provide units with capacity indicated. Provide room fan-coil units that are certified as complying with AHRI 440, and meet the requirements of UL 1995.

2.12.1.1 Enclosures

Fabricate enclosures from not lighter than 1.3 mm (18 gauge) steel, reinforced and braced. Provide enclosures with front panels that are removable and have 7 mm (1/4 inch) closed cell insulation or 13 mm (1/2 inch) thick dual density foil faced fibrous glass insulation. Make the exposed side of a high density, erosion-proof material suitable for use in air streams with velocities up to 23 m/s (4,500 fpm). Provide a discharge grille that is adjustable or fixed and that is of such design as to properly distribute air throughout the conditioned space. Plastic discharge and return grilles are acceptable provided the plastic material is certified by the manufacturer to be classified as flame resistant according to UL 94 and the material complies with the heat deflection criteria specified in UL 1995. Provide galvanized or factory finished ferrous metal surfaces with corrosion resistant enamel, and access doors or removable panels for piping and control compartments, plus easy access for filter replacement. Provide duct discharge collar for concealed models.

2.12.1.2 Fans

Provide steel or aluminum, multiblade, centrifugal type fans. In lieu of metal, fans and scrolls could be of non-metallic materials of suitably reinforced compounds with smooth surfaces. Dynamically and statically balance the fans. Provide accessible assemblies for maintenance. Disassemble and re-assemble by means of mechanical fastening devices and not by epoxies or cements.

2.12.1.3 Coils

Fabricate coils from not less than 10 mm (3/8 inch) outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Provide coils with not less than 13 mm (1/2 inch) outside diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 2000 kPa (300 psi(or under water at 1700 kPa (250 psi) air pressure. Provide coils suitable for 1400 kPa (200 psi) working pressure. Make provisions for coil removal.

2.12.1.4 Drain Pans

Size and locate drain and drip pans to collect all water condensed on and dripping from any item within the unit enclosure or casing. Provide condensate drain pans designed for self-drainage to preclude the buildup of microbial slime and thermally insulated to prevent condensation and constructed of not lighter than 0.9 mm (21 gauge) type 304 stainless steel or noncorrosive ABS plastic. Provide insulation with a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and of a waterproof type or coated with a waterproofing material. Design drain pans so as to allow no standing water and pitch to drain. Provide minimum 19 mm (3/4 inch) NPT or 15 mm)5/8 inch(OD drain connection in drain pan. Provide plastic or metal auxiliary drain pans to catch drips from control and piping packages, eliminating insulation of the packages; if metal, provide auxiliary pans that comply with the requirements specified above. Extend insulation at control and piping connections 25 mm (1 inch) minimum over the auxiliary drain pan.

2.12.1.5 Manually Operated Outside Air Dampers

Provide manually operated outside air dampers according to the arrangement indicated, and parallel airfoil type dampers of galvanized construction. Provide blades that rotate on stainless steel or nylon sleeve bearings.

2.12.1.6 Filters

Provide filters of the fiberglass disposable type, 25 mm (1 inch) thick, conforming to ASTM F1040. Filters in each unit shall be removable without the use of tools.

2.12.1.7 Motors

Provide motors of the permanent split-capacitor type with built-in thermal overload protection, directly connected to unit fans. Provide motor switch with two or three speeds and off, manually operated, and mounted on an identified plate inside the unit below or behind an access door or adjacent to the room thermostat as indicated. In lieu of the above fan speed control, a solid-state variable-speed controller having a minimum speed reduction of 50 percent is allowed. Provide motors with permanently-lubricated or oilable sleeve-type or combination ball and sleeve-type bearings with vibration isolating mountings suitable for continuous duty. Provide a motor power consumption, shown in watts, at the fan operating speed selected to meet the specified capacity that does not exceed the following values:

Free Discharge Motors			
Unit Capacity (L/S) (cfm)	Maximum Power Consumption (Watts)		
	115V	230V	277V
94 (200)	70	110	90
142 (300)	100	110	110
189 (400)	170	150	150
283 (600)	180	210	220
378 (800)	240	240	230
472 (1000)	310	250	270
566 (1200)	440	400	440

High Static Motors	
Unit Capacity (L/S) (cfm)	Maximum Power Consumption (Watts)
94 (200)	145
142 (300)	145
189 (400)	210

High Static Motors	
Unit Capacity (L/S) (cfm)	Maximum Power Consumption (Watts)
283 (600)	320
378 (800)	320
472 (1000)	530
566 (1200)	530

2.12.2 Coil Induction Units

Provide base unit that includes air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and adjustable air-balancing dampers, plus an enclosure for cabinet models and casing for concealed models. Make each unit capable of producing not less than the capacity indicated without exceeding the indicated static pressure. Provide a sound power level as indicated with power level data or values for these units based on tests conducted according to ASA S12.51. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. The values obtained for the standard cabinet models are acceptable for concealed models without separate tests, provided there is no variation between models as to coil configuration, air discharge nozzles, air balancing dampers, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Secure each unit to the building structure. Provide units with capacity indicated.

2.12.2.1 Enclosures

Fabricate enclosures from not lighter than 1.2 mm (18 gauge) steel, reinforced and braced. Provide a removable front panel of enclosure and insulate when required acoustically and to prevent condensation. Provide discharge grilles that are adjustable or integrally stamped and properly distribute air throughout the conditioned space. Plastic discharge and return grilles are not acceptable. Provide access doors for all piping and control compartments.

2.12.2.2 Air Plenums

Fabricate plenums from galvanized steel with interior acoustically baffled and lined with sound absorbing material to attenuate the sound power from the primary air supply to the room. Provide heat-resistant nozzles that are integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, furnish a streamlined, vaned, mitered elbow transition piece for connection between the unit and ductwork. Provide an adjustable air-balancing damper in each unit.

2.12.2.3 Coils

Fabricate coils from not less than 10 mm (3/8 inch) outside diameter seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes. Furnish coil connections with not less than 13 mm (1/2 inch) outside diameter flare or sweat connectors, accessory piping package with terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 2000 kPa (300 psi) or under water at 1700 kPa (250 psi) air pressure and provide coils suitable for 1400 kPa (200 psi) working pressure.

2.12.2.4 Screens

Provide easily accessible lint screens or throwaway filters for each unit.

2.12.2.5 Drain Pan

Size and locate drain and drip pans to collect condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 0.9 mm (21 gauge) steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that has a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and that is a waterproof type or coated with a waterproofing material. In lieu of the above, drain pans constructed of die-formed 0.8 mm (22 gauge) steel are allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 0.9 mm (21 gauge) steel material or of die-formed 0.9 mm (21 gauge) type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Provide drain connection when a condensate drain system is indicated. Make connection a minimum 19 mm (3/4 inch) NPT or 15 mm (5/8 inch) OD.

2.12.3 Variable Air Volume (VAV) and Dual Duct Terminal Units

a. Provide VAV and dual duct terminal units that are the type, size, and capacity shown, mounted in the ceiling or wall cavity, plus units that are suitable for single or dual duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

b. Provide unit enclosures that are constructed of galvanized steel not lighter than 0.85 mm (22 gauge) or aluminum sheet not lighter than 1.3 mm (18 gauge). Provide single or multiple discharge outlets as required. Units with flow limiters are not acceptable. Provide unit air volume that is factory preset and readily field adjustable without special tools. Provide reheat coils as indicated.

c. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to AHRI 880 I-Pwith the calculations prepared in accordance with AHRI 885. Provide sound power level as indicated. Show discharge sound power for minimum and 375 Pa (1-1/2 inches water gauge) inlet static pressure. Provide acoustical lining according to NFPA 90A.

2.12.3.1 Constant Volume, Single Duct Terminal Units

Provide constant volume, single duct, terminal units that contain within the casing, a constant volume regulator. Provide volume regulators that control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 200 to 1500 Pa (3/4 to 6 inch water gauge).

2.12.3.2 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Provide units that control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 200 to 1500 Pa (3/4 to 6 inch water gauge). Provide units with an internal resistance not exceeding 100 Pa (0.4 inch water gauge) at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 250 Pa (0 to 1 inch water gauge) range.

2.12.3.3 Variable Volume, Single Duct, Fan-Powered Terminal Units

Provide variable volume, single duct, fan-powered terminal units with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Provide units that control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 200 to 1500 Pa (3/4 to 6 inch water gauge). Provide unit fan that is centrifugal, direct-driven, double-inlet type with forward curved blades. Provide either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type fan motor. Isolate fan/motor assembly from the casing to minimize vibration transmission. Provide factory furnished fan control that is wired into the unit control system. Provide a factory-mounted pressure switch to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.12.3.4 Dual Duct Terminal Units

Provide dual duct terminal units with hot and cold inlet valve or dampers that are controlled in unison by single or dual actuators. Provide actuator as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Provide unit that controls delivered air volumes within plus or minus 5 percent with inlet air variations from 250 to 2000 Pa (1 to 8 inch water gauge) in either duct. Include mixing baffles with the unit casing. Provide cabinet and closed duct leakage that does not exceed 2 percent of maximum rated air volume. Provide units with an internal resistance at maximum flow range that does not exceed water gauge reading indicated.

2.12.3.5 Ceiling Induction Terminal Units

Provide ceiling induction unit with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Arrange unit to induce air from the ceiling plenum to maintain a maximum total flow circulated to the conditioned space. Vary primary air upon demand of the room thermostat. Upon a demand for maximum cooling, provide a unit that delivers 100 percent primary air and, at minimum cooling, delivers 25 percent primary air. Provide a terminal unit capable of closing to full shut off without additional actuators or linkage changes. Provide terminals that reset primary air volume within plus or minus 5 percent determined by the thermostat regardless of upstream changes in the static pressure. Provide a minimum inlet static pressure that does not exceed 250 Pa (1 inch water gauge)_, including a maximum of 75 Pa)0.3 inch water gauge_ downstream static pressure. Provide external differential pressure taps separate from control pressure taps for primary air flow measurement with 0 to 250 Pa (0 to 1 inch water gauge)_ range. Make each unit normally closed upon loss of pneumatic pressure. Factory pipe actuator and accuracy controls requiring only field installation of 138 kPa)20 psi_ pneumatic main air and room thermostat.

2.12.3.6 Series Fan Powered Variable Air Volume (VAV) Terminals

Provide units factory assembled, designed, tested, rated in accordance with AHRI 880 I-P, that are AHRI certified, listed in the AHRI DCAACP and that produce a supply air discharge mix by modulation of conditioned primary air and recirculating of return air. Provide units that include casing, centrifugal fan and motor, primary VAV damper or valve, electronic volume regulator, discharge air damper, primary air inlet cone with high and low pressure flow sensors, recirculating air filter frames, filter, and electrical disconnect. Provide hot water heating coils integral to the terminal, or provide insulated hot water coil section attached to the discharge of the terminal.

a. Casing: Provide removable full bottom access panels for servicing internal components without disturbing duct connections. Insulate inside of casing with manufacturer's standard insulation. Provide units that have recirculating air inlet equipped with filter frame, round primary damper or valve, and unit mounting brackets.

b. Fans and motors: Provide centrifugal, forward curved, multiblade, fan wheels with direct-drive motors. Provide motors that are the high efficiency permanent-split capacitor type with thermal overload protection, permanently lubricated bearings, and have three speeds or are equipped with solid state speed controllers. Provide isolation between fan motor assembly and unit casing. Provide fan and motor that is removable through casing access panel.

c. Flow sensor: Provide ring or cross type sensor with minimum of two pickup points which average the velocity across the inlet. Obtain flow measurement within plus or minus 5 percent of rated airflow with 1.5 diameters of straight duct upstream of unit and inlet static variation of 124 to 1240 Pa (0.5 to 5.0 inches water gauge). Supply flow measuring taps and calibration flowchart with each unit for field balancing airflows.

d. Primary VAV damper or valve: Provide galvanized steel damper blade that closes against gasket inside unit. Connect damper to operating shaft with a positive mechanical connection. Provide nylon bearing for damper shaft. Cylindrical die cast aluminum valve inlet tapered to fit round flexible ducts with integral flow diffuser and beveled self-centering disc. Provide damper or valve leakage at shutoff that does not exceed 2 percent of capacity at 250 Pa (1 inch water gauge) pressure.

e. Regulator: Provide electronic volume regulator. Electronic controls contained in NEMA ICS 6, Type 1 enclosure sealed from airflow. Provide unit with controls mounted on side or on air valve. System powered regulators are not permitted. Provide volume regulator that resets primary air volume as determined by thermostat, within upstream static pressure variation noted in paragraph titled "Flow Sensor." Volume regulators shall be field adjustable, factory set and calibrated to indicated maximum and minimum primary airflows, direct acting and normally closed upon loss of pneumatic pressure.

f. Electrical: Provide unit that incorporates single point electrical connection with electrical disconnect. Electrical components shall be UL or ETL listed, installed in accordance with NFPA 70 and mounted in control box. Units UL or ETL listed as an assembly do not require airflow switch interlock with electric heating coil, when factory assembled.

g. Filters: Provide UL listed throwaway 25 mm (one inch) thick fiberglass filters, standard dust-holding capacity.

2.12.3.7 Reheat Units

a. Hot Water Coils: Provide fin-and-tube type hot-water coils constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Provide headers that are constructed of cast iron, welded steel or copper. Provide casing and tube support sheets that are 1.6 mm (16 gauge), galvanized steel, formed to provide structural strength. Provide tubes that are correctly circuited for proper water velocity without excessive pressure drop and are drainable where required or indicated. At the factory, test each coil at not less than 1700 kPa (250 psi) air pressure and provide coils suitable for 1400 kPa (200 psi) working pressure. Install drainable coils in the air handling units with a pitch of not less than 10 mm per m (1/8 inch per foot) of tube length toward the drain end. Coils shall conform to the provisions of AHRI 410.

b. Steam Coils: Provide steam coils constructed of cast semisteel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered to the tubes. Roll and bush, braze or weld tubes into headers. Provide coil casings and tube support sheets, with collars of ample width, that are not lighter than 1.6 mm (16 gauge) galvanized steel formed to provide structural strength. When required, furnish multiple tube supports to prevent tube sag. Float the fin tube and header section within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide coils that are factory pressure tested and capable of withstanding 1700 kPa (250 psi) hydrostatic test pressure or 1400 kPa (250 psi) air pressure, and are for 1400 kPa 200 psi steam working pressure. Provide steam-distribution tube type preheat coils with condensing tubes having not less than 15 mm (5/8 inch) outside diameters. Provide distribution tubes that have not less than 10 mm (3/8 inch) outside diameter, with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes held securely in alignment. Limit the maximum length of a single coil to 120 times the diameter of the outside tube. Other heating coils shall be single tube type with not less than 13 mm (1/2 inch) outside diameter. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Coils shall conform to the provisions of AHRI 410.

c. Electric Resistance Heaters: Provide the duct-mounting type electric resistance heaters consisting of a nickel-chromium resistor mounted on refractory material and a steel or aluminum frame for attachment to ductwork. Provide electric duct heater that meets the requirement of Underwriters Laboratories and NFPA 70 and is provided with a built-in or surface-mounted high-limit thermostat. Interlock electric duct heaters electrically so that they cannot be energized unless the fan is running.

2.12.4 Unit Ventilators

Provide unit ventilators that include an enclosure, galvanized casing or cold-rolled steel casing with corrosion resistant coating, coil assembly, resistance heating coil assembly, valve and piping package, drain pan, air filters, fan assembly, fan drive, motor, motor controller, dampers, damper operators, and sound power level as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles, when handling standard flow for which the unit air capacity is rated. Secure each unit to the building structure. Provide the unit ventilators with capacity indicated. Provide the year-round classroom type unit ventilator with automatic controls arranged to properly heat, cool, and ventilate the room. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Make the sequence of control any one of the standard ANSI cycles specified in paragraph CONTROLS.

2.12.4.1 Enclosures

Fabricate enclosures from not lighter than 1.6 mm (16 gauge) galvanized steel, reinforced and braced, or all welded framework with panels to provide equivalent strength. Provide casing that is acoustically and thermally insulated internally with not less than 13 mm (1/2 inch) thick dual density fibrous glass insulation. Make the exposed side a high density, erosion-proof material suitable for use in air streams with velocities up to 246 m/s (4500 fpm). Fasten the insulation with waterproof, fire-resistant adhesive. Design front panel for easy removal by one person. Provide discharge grilles that have adjustable grilles or grilles with adjustable vanes and properly distribute air throughout the conditioned space. Provide return grilles that are removable where front panel does not provide access to interior components. Plastic discharge or return grilles are not acceptable. Furnish removable panels or access doors for all piping and control compartments. Provide fan switch that is key operated or accessible through a locked access panel. Install gaskets at the back and bottom of the unit for effective air seal, as required.

2.12.4.2 Electric Resistance Heating Elements

Provide electric resistance heating elements that are of the sheathed, finned, tubular type, or of the open resistance type designed for direct exposure to the air stream. Provide heating element electrical characteristics as indicated. Where fan motor or control voltage is lower than required for the electric-resistance heating element, install a fused factory mounted and wired transformer.

2.12.4.3 Fans

Provide fans that meet the requirements of ASHRAE 90.1 - SI (ASHRAE 90.1 - IP) as specified in paragraph AIR SYSTEMS EQUIPMENT. Provide galvanized steel or aluminum, multiblade, centrifugal type fans, dynamically and statically balanced. Equip fan housings with resilient mounted, self-aligning permanently lubricated ball bearings, sleeve bearings, or combination ball and sleeve bearings, capable of not less than 2000 hours of operation on one oiling. Provide direct-connected fans.

2.12.4.4 Coils

Provide coils that are circuited for a maximum water velocity of 2.4 m/s (8 fps) without excessive pressure drop and are otherwise as specified for hot water coils in paragraph TERMINAL UNITS.

2.12.4.5 Drain Pans

Size and locate drain and drip pans to collect all condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 1.2 mm (18 gauge) steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that is coated with a fire-resistant waterproofing material. In lieu of the above, drain pans constructed of die-formed 1.0 mm (20 gauge) steel is allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 1.3 mm (18 gauge) steel material, or of die-formed 1.3 mm (18 gauge) type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Furnish drain connection unless otherwise indicated. Make the minimum connection 19 mm (3/4 inch) NDT or 18 mm (5/8 inch) OD.

2.12.4.6 Filters

Fiberglass disposable type, 25 mm (1 inch) thick, rated in accordance with ASTM F1040, installed upstream of coil.

2.12.4.7 Dampers

Provide an outside air proportioning damper on each unit. In addition, provide a vane to prevent excessive outside air from entering unit and to prevent blow-through of outside air through the return air grille under high wind pressures. Where outside air and recirculated air proportioning dampers are provided on the unit, an additional vane is not required. Provide face and bypass dampers for each unit to ensure constant air volume at all positions of the dampers. Furnish each unit with a factory installed control cam assembly, pneumatic motor, or electric motor to operate the face and bypass dampers and outside air damper or outside air and recirculated air dampers in the sequence as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

2.12.4.8 Motors

Provide permanent split-capacitor type motors with built-in thermal overload protection and automatic reset. Mount motor on a resilient mounting, isolated from the casing and suitable for operation on electric service available. Provide a manually operated motor switch that provides for 2 or 3 speeds and off, mounted on an identified plate inside the unit below or behind an access door or adjacent to the room thermostat as indicated. In lieu of speed control, provide a solid state variable speed controller having minimum speed reduction of 50 percent.

2.12.4.9 Outside Air Intakes

Provide the manufacturer's standard design outside air intakes furnished with 13 mm (1/2 inch) mesh bird screen or louvers on 13 mm (1/2 inch) centers.

2.13 ENERGY RECOVERY DEVICES

2.13.1 Rotary Wheel

Provide unit that is a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream, with device performance according to ASHRAE 84 and that delivers an energy transfer effectiveness of not less than 70 percent with cross-contamination not in excess of 0.1 percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Provide exchange media that is chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Isolate exhaust and supply streams by seals which are static, field adjustable, and replaceable. Equip chain drive mechanisms with ratcheting torque limiter or slip-clutch protective device. Fabricate enclosure from galvanized steel and include provisions for maintenance access. Provide recovery control and rotation failure provisions as indicated.

2.13.2 Run-Around-Coil

Provide assembly that is factory fabricated and tested air-to-liquid-to-air energy recovery system for transfer of sensible heat from exhaust air to supply air stream and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination with maximum energy recovery at minimum life cycle cost. Computer optimize components for capacity, effectiveness, number of coil fins per inch, number of coil rows, flow rate, heat transfer rate of 25 percent by volume of ethylene or propylene glycol solution, and frost control. Provide coils that conform to paragraph AIR HANDLING UNITS. Provide related pumps, and piping specialties that conform to requirements of Section 23 63 00.00 10 COLD STORAGE REFRIGERATION SYSTEMS, Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS.

2.13.3 Heat Pipe

Provide a device that is a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination. Provide heat exchanger tube core that is 18 mm (5/8 inch) nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Provide maximum fins per unit length and number of tube rows as indicated. Provide tubes that are fitted with internal capillary wick, filled with an ANSI/ASHRAE 15 & 34, Group 1 refrigerant working fluid, selected for system design temperature range, and hermetically sealed. Provide heat exchanger frame that is constructed of not less than 1.6 mm (16 gauge) galvanized steel and fitted with intermediate tube supports, and flange connections. Provide tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio. Provide a drain pan constructed of welded Type 300 series stainless steel. Provide heat recovery regulation by system face and bypass dampers and related control system as indicated interfacing with manufacturer's standard tilt-control mechanism for summer/winter operation, regulating the supply air temperature and frost prevention on weather face of exhaust side at temperature indicated. Coil shall be fitted with pleated flexible connectors.

2.13.4 Desiccant Wheel

Provide counterflow supply, regeneration airstreams, a rotary type dehumidifier designed for continuous operation, and extended surface type wheel structure in the axial flow direction with a geometry that allows for laminar flow over the operating range for minimum air pressure differentials. Provide the dehumidifier complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor. Include a slack-side tensioner for automatic take-up for belt-driven wheels. Provide an adsorbing type desiccant material. Apply the desiccant material to the wheel such that the entire surface is active as a desiccant and the desiccant material does not degrade or detach from the surface of the wheel which is fitted with full-face, low-friction contact seals on both sides to prevent cross leakage. Provide rotary structure that has underheat, overheat and rotation fault circuitry. The wheel assembly shall come with a warranty for a minimum of five years.

2.13.5 Plate Heat Exchanger

Provide energy recovery ventilator unit that is factory-fabricated for indoor installation, consisting of a flat plate cross-flow heat exchanger, cooling coil, supply air fan and motor and exhaust air fan and motor. The casing shall be 1 mm (20 gauge) G90, galvanized steel, double wall construction with 25 mm (one inch) insulation. Provide fibrous desiccant cross-flow type heat exchanger core capable of easy removal from the unit.

2.14 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors. Provide rating of failure at the scribe mark that is not less than 6, average creepage not greater than 3 mm (1/8 inch). Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I.

Factory painting that has been damaged prior to acceptance by the Contracting Officer shall be field painted in compliance with the requirements of paragraph FIELD PAINTING OF MECHANICAL EQUIPMENT.

2.15 SUPPLEMENTAL COMPONENTS/SERVICES

2.15.1 Chilled, Condenser, or Dual Service Water Piping

The requirements for chilled, condenser, or dual service water piping and accessories are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

2.15.2 Refrigerant Piping

The requirements for refrigerant piping are specified in Section 23 23 00 REFRIGERANT PIPING.

2.15.3 Water or Steam Heating System Accessories

The requirements for water or steam heating accessories such as expansion tanks and steam traps are specified in Section 23 52 00 HEATING BOILERS.

2.15.4 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS except as modified herein.

2.15.5 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.15.6 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.15.7 Controls

The requirements for controls are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS, Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS, Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS, and 23 09 23 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of 910 mm (3 feet). In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices)and an additional 910 mm (3 feet).

c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all units, fan-coil units and coil-induction units. Provide a depth of each seal of 50 mm (2 inches) plus 0.1 mm for each Pa (the number of inches, measured in water gauge), of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 150 mm (6 inch) concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors. Submit foundation drawings as specified in paragraph DETAIL DRAWINGS. Provide concrete for foundations as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

3.2.5 Metal Ductwork

Install according to SMACNA 1966 unless otherwise indicated. Install duct supports for sheet metal ductwork according to SMACNA 1966, unless otherwise specified. Do not use friction beam clamps indicated in SMACNA 1966. Anchor risers on high velocity ducts in the center of the vertical run to allow ends of riser to move due to thermal expansion.

Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2.5.1 Underground Ductwork

Provide PVC plastisol coated galvanized steel underground ductwork with coating on interior and exterior surfaces and watertight joints. Install ductwork as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth is 2 m (6 feet).

3.2.5.2 Radon Exhaust Ductwork

Perforate subslab suction piping where indicated. Install PVC joints as specified in ASTM D2855.

3.2.5.3 Light Duty Corrosive Exhaust Ductwork

For light duty corrosive exhaust ductwork, use PVC plastisol coated galvanized steel with PVC coating on interior surfaces and exterior surfaces and epoxy wash primer coating on exterior surfaces.

3.2.6 FRP Ductwork

Provide fibrous glass reinforced plastic ducting and related structures that conform to SMACNA 1403. Provide flanged joints where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 10 degrees C (50 degrees F), heat cure joints by exothermic reaction heat packs.

3.2.7 Kitchen Exhaust Ductwork

3.2.7.1 Ducts Conveying Smoke and Grease Laden Vapors

Provide ducts conveying smoke and grease laden vapors that conform to requirements of NFPA 96. Make seams, joints, penetrations, and duct-to-hood collar connections with a liquid tight continuous external weld. Provide duct material that is a minimum 1.3 mm (18 gauge), Type 304L or 316L, stainless steel or minimum 1.6 mm 16 gauge carbon steel. Include with duct construction an external perimeter angle sized in accordance with SMACNA 1966, except place welded joint reinforcement on maximum of 600 mm (24 inch) centers; continuously welded companion angle bolted flanged joints with flexible ceramic cloth gaskets where indicated; pitched to drain at low points; welded pipe coupling-plug drains at low points; welded fire protection and detergent cleaning penetration; steel framed, stud bolted, and flexible ceramic cloth gasketed cleaning access provisions where indicated. Make angles, pipe couplings, frames, bolts, etc., the same material as that specified for the duct unless indicated otherwise.

3.2.7.2 Exposed Ductwork

Provide exposed ductwork that is fabricated from minimum 1.3 mm (18 gauge), Type 304L or 316L, stainless steel with continuously welded joints and seams. Pitch ducts to drain at hoods and low points indicated. Match surface finish to hoods.

3.2.7.3 Concealed Ducts Conveying Moisture Laden Air

Fabricate concealed ducts conveying moisture laden air from minimum 1.3 mm (18 gauge), Type 300 series, stainless steel or 1.6 mm (16 gauge), galvanized steel 0.55 mm (16 ounce), tempered copper sheet. Continuously weld, braze, or solder joints to be liquid tight. Pitch ducts to drain at points indicated. Make transitions to other metals liquid tight, companion angle bolted and gasketed.

3.2.8 Acoustical Duct Lining

Apply lining in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C916, Type I, NFPA 90A, UL 723, and ASTM E84. Provide top and bottom pieces that lap the side pieces and are secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA 1966. Provide welded pins, cup-head pins, or adhered clips that do not distort the duct, burn through, nor mar the finish or the surface of the duct. Make pins and washers flush with the surfaces of the duct liner and seal all breaks and punctures of the duct liner coating with the nonflammable, fire resistant adhesive. Coat exposed edges of the liner at the duct ends and at other joints where the lining is subject to erosion with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Apply duct liner to flat sheet metal prior to forming duct through the sheet metal brake. Additionally secure lining at the top and bottom surfaces of the duct by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA 1966 to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, are acceptable.

3.2.9 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, perform temporary dust control protection. Protect the distribution system (supply and return) with temporary seal-offs at all inlets and outlets at the end of each day's work. Keep temporary protection in place until system is ready for startup.

3.2.10 Insulation

Provide thickness and application of insulation materials for ductwork, piping, and equipment according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Externally insulate outdoor air intake ducts and plenums up to the point where the outdoor air reaches the conditioning unit or up to the point where the outdoor air mixes with the return air stream.

3.2.11 Duct Test Holes

Provide holes with closures or threaded holes with plugs in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Plug insulated duct at the duct surface, patched over with insulation and then marked to indicate location of test hole if needed for future use.

3.2.12 Power Roof Ventilator Mounting

Provide foamed 13 mm (1/2 inch) thick, closed-cell, flexible elastomer insulation to cover width of roof curb mounting flange. Where wood nailers are used, predrill holes for fasteners.

3.2.13 Power Transmission Components Adjustment

Test V-belts and sheaves for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Uniformly load belts on drive side to prevent bouncing. Make alignment of direct driven couplings to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.3 EQUIPMENT PADS

Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum 75 mm (3-inch) margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of 28 calendar days before being loaded.

3.4 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.5 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. When the work area is in an occupied space such as office, laboratory, or warehouse, protect all furniture and equipment from dirt and debris. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.6 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct 380 mm (15 inches) and smaller. Build framed, prepared openings for round duct larger than 380 mm (15 inches) and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide 25 mm (one inch) clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C553, Type 1, Class B-2.

a. Sleeves: Fabricate sleeves, except as otherwise specified or indicated, from 1 mm (20 gauge) thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A53/A53M, Schedule 20.

b. Framed Prepared Openings: Fabricate framed prepared openings from 1 mm (20 gauge) galvanized steel, unless otherwise indicated.

c. Insulation: Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below 16 degrees C (60 degrees F), provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

d. Closure Collars: Provide closure collars of a minimum 100 mm (4 inches) wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 380 mm (15 inches) in diameter or less from 1 mm (20 gauge) galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 380 mm (15 inches) from 1.40 mm (18 gauge) galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 380 mm (15 inches) or less from 1 mm (20 gauge) galvanized steel. Install collars with fasteners a maximum of 150 mm (6 inches) on center. Attach to collars a minimum of 4 fasteners where the opening is 300 mm (12 inches) in diameter or less, and a minimum of 8 fasteners where the opening is 500 mm (20 inches) in diameter or less.

e. Firestopping: Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.7 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 50 degrees C (120 degrees F). Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

a. Temperatures less than 50 degrees C (120 degrees F): Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm (0.3 mil), one coat of primer applied to a minimum dry film thickness of 0.0255 mm (one mil); and two coats of enamel applied to a minimum dry film thickness of 0.0255 mm (one mil) per coat to metal surfaces subject to temperatures less than 50 degrees C (120 degrees F).

b. Temperatures between 50 and 205 degrees C (120 and 400 degrees F): Apply two coats of 205 degrees C (400 degrees F) heat-resisting enamel applied to a total minimum thickness of 0.05 mm (two mils) to metal surfaces subject to temperatures between 50 and 205 degrees C (120 and 400 degrees F).

c. Temperatures greater than 205 degrees C (400 degrees F): Apply two coats of 315 degrees C (600 degrees F) heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm (two mils) to metal surfaces subject to temperatures greater than 205 degrees C (400 degrees F).

3.7.1 Finish Painting

The requirements for finish painting of items only primed at the factory, and surfaces not specifically noted otherwise, are specified in Section 09 90 00 PAINTS AND COATINGS.

3.7.2 Color Coding Scheme for Locating Hidden Utility Components

Use scheme in buildings having suspended grid ceilings. Provide color coding scheme that identifies points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid, consisting of a color code board and colored metal disks. Make each colored metal disk approximately 13 mm (3/8 inch) diameter and secure to removable ceiling panels with fasteners. Insert each fastener into the ceiling panel so as to be concealed from view. Provide fasteners that are manually removable without the use of tools and that do not separate from the ceiling panels when the panels are dropped from ceiling height. Make installation of colored metal disks follow completion of the finished surface on which the disks are to be fastened. Provide color code board that is approximately 1 m (3 foot) wide, 750 mm (30 inches) high, and 13 mm (1/2 inches) thick. Make the board of wood fiberboard and frame under glass or 1.6 mm (1/16 inch) transparent plastic cover. Make the color code symbols approximately 19 mm (3/4 inch) in diameter and the related lettering in 13 mm (1/2 inch) high capital letters. Mount the color code board where indicated or in the mechanical or equipment room.

3.8 IDENTIFICATION SYSTEMS

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 35 mm (1-3/8 inch) minimum diameter with stamped or engraved markings. Make indentations black for reading clarity. Attach tags to valves with No. 12 AWG 2 mm (0.0808-inch) diameter corrosion-resistant steel wire, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.9 DUCTWORK LEAK TEST

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, filters, etc. designated as static pressure Class 750 Pa (3 inch water gauge) through Class 2500 Pa (10 inch water gauge). Provide test procedure, apparatus, and report that conform to SMACNA 1972 CD. Complete ductwork leak test with satisfactory results prior to applying insulation to ductwork exterior.

3.10 DAMPER ACCEPTANCE TEST

Submit the proposed schedule, at least 2 weeks prior to the start of test. Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.11 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.12 PERFORMANCE TESTS

After testing, adjusting, and balancing is complete as specified, test each system as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Record the testing during the applicable season. Make corrections and adjustments as necessary to produce the conditions indicated or specified. Conduct capacity tests and general operating tests by an experienced engineer. Provide tests that cover a period of not less than 5 days for each system and demonstrate that the entire system is functioning according to the specifications. Make coincidental chart recordings at points indicated on the drawings for the duration of the time period and record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

Submit test reports for the ductwork leak test, and performance tests in booklet form, upon completion of testing. Document phases of tests performed including initial test summary, repairs/adjustments made, and final test results in the reports.

3.13 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of room fan-coil units, coil-induction units, air terminal units, or unit ventilators, thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and install new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions.

Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.14 OPERATION AND MAINTENANCE

3.14.1 Operation and Maintenance Manuals

Submit one hard copy and one digital copy (.pdf - text searchable) of operation and maintenance manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed below, if applicable.

a. Fire Dampers

b. Manual Balancing Dampers

c. Centrifugal Fans

d. In-Line Centrifugal Fans

e. Axial Flow Fans

f. Panel Type Power Wall Ventilators

g. Centrifugal Type Power Wall Ventilators

h. Centrifugal Type Power Roof Ventilators

i. Propeller Type Power Roof Ventilators

j. Air-Curtain Fans

k. Ceiling Exhaust Fans

l. Air Handling Units

m. Room Fan-Coil Units

n. Coil Induction Units

o. Constant Volume, Single Duct Terminal Units

p. Variable Volume, Single Duct Terminal Units

q. Variable Volume, Single Duct, Fan-Powered Terminal Units

r. Dual Duct Terminal Units

s. Ceiling Induction Terminal Units

t. Reheat Units

u. Unit Ventilators

v. Energy Recovery Devices

3.14.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of 40 hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals and at least 14 days prior to conducting the training course.

-- End of Section --

SECTION 23 03 00.00 20

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2014) Motors and Generators
NEMA MG 10	(2013) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	Scientific Certification Systems (SCS)Indoor Advantage

UL ENVIRONMENT (ULE)

ULE Greenguard	UL Greenguard Certification Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Certification

1.3 RELATED REQUIREMENTS

This section applies to all sections of Divisions: 21, FIRE SUPPRESSION; 22, PLUMBING; and 23, HEATING, VENTILATING, AND AIR CONDITIONING of this project specification, unless specified otherwise in the individual section.

1.4 QUALITY ASSURANCE

1.4.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.4.2 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.4.3 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4.4 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.4.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4.5.3 Sustainable Design Certification

Product shall be third party certified by ULE Greenguard Greenguard Indoor Air Quality Certified, SCS Scientific Certification Systems Indoor Advantage or equal. Certification shall be performed annually and shall be current.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors shall conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and shall have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work shall be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.7 ELECTRICAL INSTALLATION REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.7.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters (except starters/controllers which are indicated as part of a motor control center), control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, the motor control equipment forming a part of motor control centers, and the electrical power circuits shall be provided under Division 26, except internal wiring for components of package equipment shall be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.7.2 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 26.

1.7.3 High Efficiency Motors

1.7.3.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.7.3.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors shall be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings shall meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.7.4 Three-Phase Motor Protection

Provide controllers for motors rated one 1.34 kilowatts (1 horsepower) and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and over-voltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

1.8 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.9 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 3 mm (0.125 inch) on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C (120 degrees F), the factory painting system shall be designed for the temperature service.

3.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 50 degrees C (120 degrees F) shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 50 Degrees C (120 Degrees F): Immediately after cleaning, the metal surfaces subject to temperatures less than 50 degrees C (120 degrees F) shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm (0.3 mil), one coat of primer applied to a minimum dry film thickness of 0.0255 mm (1 mil); and two coats of enamel applied to a minimum dry film thickness of 0.0255 mm (1 mil) per coat.

b. Temperatures Between 50 and 205 Degrees C (120 and 400 Degrees F): Metal surfaces subject to temperatures between 50 and 205 degrees C (120 and 400 degrees F) shall receive two coats of 205 degrees C (400 degrees F) heat-resisting enamel applied to a total minimum thickness of 0.05 mm (2 mils).

c. Temperatures Greater Than 205 Degrees C (400 Degrees F): Metal surfaces subject to temperatures greater than 205 degrees C (400 degrees F) shall receive two coats of 315 degrees C (600 degrees)F heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm (2 mils).

-- End of Section --

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.11 PART 1	(2014) American National Standard Electroacoustics – Octave-Band and Fractional-Octave-Band Filters – Part 1: Specifications
ASA S1.4	(1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 203	(1990; R 2011) Field Performance Measurements of Fan Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 62.1	(2010; Errata 2011; INT 3 2012; INT 4 2012; INT 5 2013) Ventilation for Acceptable Indoor Air Quality
ASHRAE HVAC APP IP HDBK	(2011) HVAC Applications Handbook, I-P Edition
ASHRAE HVAC APP SI HDBK	(2011) HVAC Applications Handbook, SI Edition

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(2002; 6th ed) National Standards for Total System Balance
AABC MN-4	(1996) Test and Balance Procedures

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB MASV	(2006) Procedural Standards for Measurements and Assessment of Sound and Vibration
NEBB PROCEDURAL STANDARDS	(2005) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 1858	(2004) HVAC Sound And Vibration Manual - First Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

1.2 DEFINITIONS

a. AABC: Associated Air Balance Council.

b. COTR: Contracting Officer's Technical Representative.

c. DALT: Duct air leakage test

d. DALT'd: Duct air leakage tested

e. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling.

f. NEBB: National Environmental Balancing Bureau

g. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction and sealant class." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."

h. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 17.5 degrees Celsius (plus or minus 30 degrees Fahrenheit) of the project site's winter outdoor design temperature, throughout the period of TAB data recording.

i. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within plus or minus 3 degrees Celsius(plus or minus 5 degrees Fahrenheit) of the project site's summer outdoor design temperature, throughout the period of TAB data recording.

j. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.

k. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).

l. TAB: Testing, adjusting, and balancing (of HVAC systems).

m. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed.

n. TAB Agency: TAB Firm

o. TAB team field leader: TAB team field leader

p. TAB team supervisor: TAB team engineer.

q. TAB team technicians: TAB team assistants.

r. TABB: Testing Adjusting and Balancing Bureau.

1.2.1 Similar Terms

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results.

The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	International Standards for Environmental Systems Balance
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

1.3 WORK DESCRIPTION

The work includes duct air leakage testing (DALT) and testing, adjusting, and balancing (TAB) of new and existing heating, ventilating, and cooling (HVAC) air and water distribution systems including equipment and performance data, ducts, and piping which are located within, on, under, between, and adjacent to buildings, including records of existing conditions.

Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct DALT testing in compliance with the requirements specified in SMACNA 1972 CD, except as supplemented and modified by this section. Conduct DALT and TAB work in accordance with the requirements of this section.

1.3.1 Air Distribution Systems

Test, adjust, and balance systems (TAB) in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to exterior of air distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.2 Water Distribution Systems

TAB systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to water distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. At Contractor's option and with Contracting Officer's written approval, the piping systems may be insulated before systems are TAB'd.

Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.

After completion of work under this section, insulate the flow control valves and devices as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.3 TAB SCHEMATIC DRAWINGS

Show the following information on TAB Schematic Drawings:

1. A unique number or mark for each piece of equipment or terminal.

2. Air quantities at air terminals.

3. Air quantities and temperatures in air handling unit schedules.

4. Water quantities and temperatures in thermal energy transfer equipment schedules.

5. Water quantities and heads in pump schedules.

6. Water flow measurement fittings and balancing fittings.

7. Ductwork Construction and Leakage Testing Table that defines the DALT test requirements, including each applicable HVAC duct system ID or mark, duct pressure class, duct seal class, and duct leakage test pressure. This table is included in the file for Graphics for Unified Facilities Guide Specifications: http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf

The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

Submit one hard copy & one digital copy (.pdf - text searchable) of the TAB Schematic Drawings and Report Forms to the Contracting Officer, no later than 21 days prior to the start of TAB field measurements.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Records of Existing Conditions; G

TAB Firm; G

Designation of TAB team assistants; G

Designation of TAB team engineer; G or TAB Specialist; G

Designation of TAB team field leader; G

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G

SD-03 Product Data

Equipment and Performance Data; G

TAB Related HVAC Submittals; G

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB team engineer and assistant.

TAB Procedures; G

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration; G

Systems Readiness Check; G

TAB Execution; G

TAB Verification; G

SD-06 Test Reports

Design review report; G

Pre-Final DALT report; G

Final DALT report; G

TAB report for Season 1; G

TAB report for Season 2; G

SD-07 Certificates

TAB Firm; G

Independent TAB Agency and Personnel Qualifications; G

DALT and TAB Submittal and Work Schedule; G

Design review report; G

Pre-field DALT preliminary notification; G

Pre-field TAB engineering report; G

Advanced notice for Season 1 TAB field work; G

Prerequisite HVAC Work Check Out List For Season 1; G

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

To secure approval for the proposed agency, submit information certifying that the TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, or construction. Further, submit the following, for the agency, to Contracting Officer for approval:

a. Independent AABC or NEBB or TABB TAB agency:

TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.

TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.

TAB team field leader: Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.

TAB team field technicians: Names and documented evidence that each field technician has satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification are not to perform TAB work on this contract.

b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel is allowed to do TAB work on this contract.

c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.5.2 TAB Standard

Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations.

All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of ASHRAE 62.1.

1.5.3 Qualifications

1.5.3.1 TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems, the performance of clean rooms and clean air devices, building systems commissioning ,and/or the measuring of sound and vibration in environmental systems, as indicated on contract drawings and documents.

Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.

1.5.3.2 TAB Specialist

The TAB Specialist must be either a member of AABC, an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification must be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist will be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.5.3.3 TAB Specialist Responsibilities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process specified in Section 23 08 00.00 10 COMMISSIONING OF HVAC SYSTEMS.

1.5.3.4 TAB Related HVAC Submittals

The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Government. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

1.5.4 Responsibilities

The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in paragraph entitled "TAB Submittal and Work Schedule."

1.5.4.1 Contractor

a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in paragraph entitled "TAB Personnel Qualification Requirements."

b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheet metal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.

c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:

(1) Contract drawings and specifications

(2) Approved submittal data for equipment

(3) Construction work schedule

(4) Up-to-date revisions and change orders for the previously listed items

d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in paragraph entitled "TAB Submittal and Work Schedule," is met.

e. Coordination of supporting personnel:

Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.

Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the DALT and the TAB field work.

Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.

f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.

g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.

h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.

(1) HVAC system installations are fully complete.

(2) HVAC prerequisite checkout work lists specified in the paragraph "Pre-Field TAB Engineering Report" are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.

(3) DALT field checks for all systems are completed.

(4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.

i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.

j. Insulation work: For required DALT work , ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.4.2 TAB Agency

Provide the services of a TAB team which complies with the requirements of paragraph entitled "Independent TAB Agency Personnel Qualifications". The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

1.5.4.3 TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Pre-DALT/TAB meeting: Attend meeting with Contractor.

c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.

e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Contracting Officer.

f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.

g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.

h. Technical assistance for DALT work.

(1) Technical assistance: Provide immediate technical assistance to TAB field team.

(2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of two 8 hour workdays duration.

i. Final DALT report: Certify the DALT report. This certification includes the following work:

(1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.

(2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.

j. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.

(1) TAB field visit (TAB field work): At the midpoint of the Season 1 and Season 2 TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration. If indicated on drawings, Contractor may accomplish TAB field work and TAB quality assurance on same trip.

(2) TAB field visit (TAB quality assurance): Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration. Review the TAB final report data and certify the TAB final report.

k. Certified TAB report: Certify the TAB report. This certification includes the following work:

(1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.

(2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

l. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the

TAB Supervisor must submit written notification directly to the Contracting Officer, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.

m. TAB Field Check: The TAB team supervisor must attend and supervise Season 1 and Season 2 TAB field check, unless otherwise indicated on contract drawings and documents.

1.5.4.4 TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, "Execution."

b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

1.5.5 Test Reports

1.5.5.1 Data from DALT Field Work

Report the data for the Pre-final DALT Report and Certified Final DALT Report in compliance the following requirements:

a. Report format: Submit report data on Air Duct Leakage Test Summary Report Forms as shown on Page 6-2 of SMACNA 1972 CD. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.

b. The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition, provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.

c. Instruments: List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to the measuring standards of the National Institute of Standards and Technology.

d. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

1.5.5.2 Certified TAB Reports

Submit: TAB Report for Season 1 and TAB Report for Season 2 in the following manner:

a. Report format: Submit the completed pre-field data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.

b. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:

(1) Measure and compile data on a continuous basis for the period in which TAB work affecting those rooms is being done.

(2) Measure and record data only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode.

(3) Data may be compiled using direct digital controls trend logging where available. Otherwise, temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls must be fully operational a minimum of 24 hours in advance of commencing data compilation. Include the specified data in the Season I and Season 2 TAB Report.

c. System Diagrams: Provide updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations. Use a key numbering system on the diagram which identifies each outlet contained in the outlet airflow report sheets.

d. Static Pressure Profiles: Report static pressure profiles for air duct systems indicated. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. Include the following in the static pressure report data, in addition to AABC/NEBB/TABB required data:

(1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.

(2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.

(3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.

(4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers.

Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.

(5) Report static pressure drop across outside air and relief/exhaust air louvers.

(6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit and also at the following locations:

Main Duct: Take readings at four locations along the full length of the main duct, 25 percent, 50 percent, 75 percent, and 100 percent of the total duct length.

Floor Branch Mains: Take readings at floor branch mains served by a main duct vertical riser.

Branch Main Ducts: Take readings at branch main ducts.

VAV Terminals: Take readings at inlet static pressure at VAV terminal box primary air branch ducts.

VAV Terminals, Fan Powered: Take readings at fan discharge and inlet static pressures for series and parallel fan powered VAV terminal boxes.

e. Duct Traverses: Report duct traverses for main and branch main supply, return, exhaust, relief and outside air ducts. This includes all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane."

f. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

Instrumentation, used for taking wet bulb temperature readings must provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

g. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

h. Performance Curves: The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.

i. Calibration Curves: The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturis and flow orifices TAB'd on the job.

1.6 PROJECT/SITE CONDITIONS

1.6.1 DALT and TAB Services to Obtain Existing Conditions

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct this DALT and TAB work in accordance with the requirements of this section.

1.7 SEQUENCING AND SCHEDULING

1.7.1 Projects with Phased Construction

This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.

1.7.1.1 Phasing of Work

This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase in spite of the fact that there will be two seasons. All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed and approved by the Contracting Officer with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.

1.7.2 DALT and TAB Submittal and Work Schedule

Submit this schedule, and TAB Schematic Drawings adapted for this particular contract, to the Contracting Officer (KO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for KO approval every 90 calendar days. Compliance with the following schedule is the Contractor's responsibility.

Qualify TAB Personnel: Within 45 calendar days after date of contract award, submit TAB agency and personnel qualifications.

Pre-DALT/TAB Meeting: Within 30 calendar days after the date of approval of the TAB agency and personnel, meet with the COTR.

Design Review Report: Within 60 calendar days after the date of the TAB agency personnel qualifications approval, submit design review report.

Pre-Field DALT Preliminary Notification: On completion of the duct installation for each system, notify the Contracting Officer in writing within 5 days after completion.

Ductwork Selected for DALT: Within 7 calendar days of Pre-Field DALT Preliminary Notification, the COTR will select which of the project ductwork must be DALT'd.

DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected.

Submit Pre-final DALT Report: Within one working day after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.

DALT Work Field Check: Upon approval of the Pre-final DALT Report, schedule the COTR's DALT field check work with the Contracting Officer.

Submit Final DALT Report: Within 15 calendar days after completion of successful DALT Work Field Check, submit Season 1 TAB report.

Pre-Field TAB Engineering Report: Within 30 calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.

Prerequisite HVAC Work Check Out List For Season 1 and Advanced Notice For Season 1 TAB Field Work: At a minimum of 115 calendar days prior to CCD, submit Season 1 prerequisite HVAC work check out list certified as complete, and submit advance notice of commencement of Season 1 TAB field work.

Season 1 TAB Field Work: At a minimum of 90 calendar days prior to CCD, and when the ambient temperature is within Season 1 limits, accomplish Season 1 TAB field work.

Submit Season 1 TAB Report: Within 15 calendar days after completion of Season 1 TAB field work, submit Season 1 TAB report, unless otherwise indicated on contract drawings and documents.

Season 1 TAB Field Check: 30 calendar days after Season 1 TAB report is approved by the Contracting Officer, conduct Season 1 field check, unless otherwise indicated on contract drawings and documents.

Complete Season 1 TAB Work: Prior to CCD, complete all TAB work except Season 2 TAB work.

1.7.2.1 Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.7.2.2 Pre-Field DALT Preliminary Notification

Notification: On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing within 7 calendar days after completion.

1.7.2.3 Pre-Field TAB Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

(1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.

(2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.

(3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:

(1) Design data obtained from system drawings, specifications, and approved submittals.

(2) Notations detailing additional data to be obtained from the contract site by the TAB field team.

(3) Designate the actual data to be measured in the TAB field work.

(4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

At a minimum, a list of the applicable inspections and work items listed in the NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System

Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

1.8 WARRANTY

Furnish workmanship and performance warranty for the DALT and TAB system work performed for a period not less than 2 years from the date of Government acceptance of the work; issued directly to the Government. Include provisions that if within the warranty period the system shows evidence of major performance deterioration, or is significantly out of tolerance, resulting from defective TAB or DALT workmanship, the corrective repair or replacement of the defective materials and correction of the defective workmanship is the responsibility of the TAB firm. Perform corrective action that becomes necessary because of defective materials and workmanship while system TAB and DALT is under warranty 7 days after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within the specified period of time constitutes grounds for having the corrective action and repairs performed by others and the cost billed to the TAB firm. The Contractor must also provide a 2 year contractor installation warranty.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section.

3.2 PRE-DALT/TAB MEETING

Meet with the Contracting Officer's technical representative (COTR) and the designing engineer of the HVAC systems to develop a mutual understanding relative to the details of the DALT work and TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

3.3 DALT PROCEDURES

3.3.1 Instruments, Consumables and Personnel

Provide instruments, consumables and personnel required to accomplish the DALT field work. Follow the same basic procedure specified below for TAB Field Work, including maintenance and calibration of instruments, accuracy of measurements, preliminary procedures, field work, workmanship and treatment of deficiencies. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

3.3.2 Advance Notice of Pre-Final DALT Field Work

On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing prior to the COTR's duct selection field visit.

3.3.3 Ductwork To Be DALT'd

From each duct system indicated as subject to DALT, the COTR will randomly select sections of each completed duct system for testing by the Contractor's TAB Firm. The sections selected will not exceed 20 percent of the total measured linear footage of duct systems indicated as subject to DALT. Sections of duct systems subject to DALT will include 20 percent of main ducts, branch main ducts, branch ducts and plenums for supply, return, exhaust, and plenum ductwork.

It is acceptable for an entire duct system to be DALT'd instead of disassembling that system in order to DALT only the 20 percent portion specified above.

3.3.4 DALT Testing

Perform DALT on the HVAC duct sections of each system as selected by the COTR. Use the duct class, seal class, leakage class and the leak test pressure data indicated on the drawings, to comply with the procedures specified in SMACNA 1972 CD.

In spite of specifications of SMACNA 1972 CD to the contrary, DALT ductwork of construction class of 746 Pa (3-inch) water gauge static pressure and below if indicated to be DALT'd. Complete DALT work on the COTR selected ductwork within 48 hours after the particular ductwork was selected for DALT. Separately conduct DALT work for large duct systems to enable the DALT work to be completed in 48 hours.

3.3.5 Pre-final DALT Report

After completion of the DALT work, prepare a Pre-final DALT Report using the reporting forms specified. TAB team to furnish data required by those data report forms . Prepare the report neatly and legibly; the Pre-final DALT report is the basis for the Final DALT Report. TAB supervisor must review and certify the Pre-final DALT Report and submit this report within one day of completion of DALT field work. Verbally notify the COTR that the field check of the Pre-final DALT Report data can commence.

3.3.6 Quality Assurance - COTR DALT Field Acceptance Testing

In the presence of the COTR and TAB team field leader, verify for accuracy Pre-final DALT Report data selected by the COTR. For each duct system, this acceptance testing shall be conducted on a maximum of 50 percent of the duct sections DALT'd.

Further, if any data on the Pre-final DALT report form for a given duct section is out-of-tolerance, then field acceptance testing shall be conducted on data for one additional duct section, preferably in the same duct system, in the presence of the COTR.

3.3.7 Additional COTR Field Acceptance Testing

If any of the duct sections checked for a given system are determined to have a leakage rate measured that exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction class and sealant class, terminate data checking for that section. The associated Pre-final DALT Report data for the given duct system will be disapproved. Make the necessary corrections and prepare a revised Pre-final DALT Report. Reschedule a field check of the revised report data with the COTR.

3.3.8 Certified Final DALT Report

On successful completion of all field checks of the Pre-final DALT Report data for all systems, the TAB Supervisor is to assemble, review, certify and submit the Final DALT Report to the Contracting Officer for approval.

3.3.9 Prerequisite for TAB Field Work

Do not commence TAB field work prior to the completion and approval, for all systems, of the Final DALT Report.

3.4 TAB PROCEDURES

3.4.1 TAB Field Work

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.

That is, comply with the requirements of AABC MN-1 , or SMACNA 1780 (TABB) and SMACNA 1858 (TABB),except as supplemented and modified by this section.

Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and AABC MN-4, or NEBB TABES and NEBB MASV, or SMACNA 1780 (used by TABB) and SMACNA 1858 sound measurement procedures, except as supplemented and modified by this section. The only water flow and air flow reporting which can be deferred until the Season 2 is that data which would be affected in terms of accuracy due to outside ambient conditions.

3.4.2 Preliminary Procedures

Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.4.3 TAB Air Distribution Systems

3.4.3.1 Units With Coils

Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For air handlers with capacities greater than 26,370 Watts (7.5 tons (90,000 Btu)) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

Do not determine entering and leaving wet and dry bulb temperatures by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 26370 Watts (7.5 tons (90,000 Btu)) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.3.2 Air Handling Units

Air handling unit systems including fans (air handling unit fans, exhaust fans and winter ventilation fans), coils, ducts, plenums, mixing boxes, terminal units, variable air volume boxes, and air distribution devices for supply air, return air, outside air, mixed air relief air, and makeup air.

3.4.3.3 Rooftop Air Conditioning

Rooftop air conditioning systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

For refrigeration compressors/condensers/condensing units/evaporators, report data as required by NEBB, AABC, and TABB standard procedures, including refrigeration operational data.

3.4.3.4 Heating and Ventilating Units

Heating and ventilating unit systems including fans, coils, ducts, plenums, roof vents, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.3.5 Makeup Air Units

Makeup air unit systems including fans, coils, ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.3.6 Return Air Fans

Return air fan system including fan ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.3.7 Fan Coils

Fan coil unit systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

3.4.3.8 Exhaust Fans

Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust air.

3.4.4 TAB Water Distribution Systems

3.4.4.1 Chilled Water

Chilled water systems including chillers, condensers, cooling towers, pumps, coils, system balance valves and flow measuring devices.

For water chillers, report data as required by AABC, NEBB and TABB standard procedures, including refrigeration operational data.

3.4.4.2 Heating Hot Water

Heating hot water systems including boilers, hot water converters (e.g., heat exchangers), pumps, coils, system balancing valves and flow measuring devices.

3.4.4.3 Dual Temperature Water

Dual temperature water systems including boilers, converters, chillers, condensers, cooling towers, pumps, coils, and system balancing valves, and flow measuring devices.

3.4.5 Sound Measurement Work

3.4.5.1 Areas To Be Sound Measured

In the following spaces, measure and record the sound power level for each octave band listed in ASHRAE HVAC APP SI HDBK (ASHRAE HVAC APP IP HDBK) Noise Criteria:

a. All HVAC mechanical rooms, including machinery spaces and other spaces containing HVAC power drivers and power driven equipment.

b. All spaces sharing a common barrier with each mechanical room, including rooms overhead, rooms on the other side of side walls, and rooms beneath the mechanical room floor.

c. AHU No. 1 System: Rooms: _____

3.4.5.2 Procedure

Measure sound levels in each room, when unoccupied except for the TAB team, with all HVAC systems that would cause sound readings in the room operating in their noisiest mode. Record the sound level in each octave band. Attempt to mitigate the sound level and bring the level to within the specified ASHRAE HVAC APP SI HDBK (ASHRAE HVAC APP IP HDBK) noise criteria goals, if such mitigation is within the TAB team's control. State in the report the ASHRAE HVAC APP SI HDBK (ASHRAE HVAC APP IP HDBK) noise criteria goals. If sound level cannot be brought into compliance, provide written notice of the deficiency to the Contractor for resolution or correction.

3.4.5.3 Timing

Measure sound levels at times prescribed by AABC or NEBB or TABB.

3.4.5.4 Meters

Measure sound levels with a sound meter complying with ASA S1.4, Type 1 or 2, and an octave band filter set complying with ASA S1.11 PART 1. Use measurement methods for overall sound levels and for octave band sound levels as prescribed by NEBB.

3.4.5.5 Calibration

Calibrate sound levels as prescribed by AABC or NEBB or TABB, except that calibrators emitting a sound pressure level tone of 94 dB at 1000 hertz (Hz) are also acceptable.

3.4.5.6 Background Noise Correction

Determine background noise component of room sound (noise) levels for each (of eight) octave bands as prescribed by AABC or NEBB or TABB.

3.4.6 TAB Work on Performance Tests Without Seasonal Limitations

3.4.6.1 Performance Tests

In addition to the TAB proportionate balancing work on the air distribution systems and the water distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the heating systems and cooling systems.

3.4.6.2 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.4.6.3 Sound Measurements

Comply with paragraph entitled "Sound Measurement Work," specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

3.4.7 TAB Work on Performance Tests With Seasonal Limitations

3.4.7.1 Performance Tests

Accomplish proportionate balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.

3.4.7.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for TAB field measurements. Visit the contract site during the season of maximum heating load and visit the contract site during the season of maximum cooling load, the goal being to TAB the operational performance of the heating systems and cooling systems under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the heating systems and cooling systems.

3.4.7.3 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.4.7.4 Sound Measurements

Comply with paragraph entitled "Sound Measurement Work," specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

3.4.7.5 Water Chillers

Water chillers: For water chillers, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

3.4.7.6 Refrigeration Units

For refrigeration compressors/condensers/condensing units, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

3.4.7.7 Coils

Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For Central station air handlers with capacities greater than 26,370 Watts (7.5 tons (90,000 Btu)) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

   Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 26370 Watts (7.5 tons (90,000 Btu)) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

   Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.8 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

3.4.9 Deficiencies

Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph entitled "Workmanship," provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction.

Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.4.10 TAB Reports

After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and certification, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph entitled "Workmanship."

Verbally notify the COTR that the field check of the TAB report data can commence; give this verbal notice 48 hours in advance of field check commencement. Do not schedule field check of the TAB report until the specified workmanship requirements have been met or written approval of the deviations from the requirements have been received from the Contracting Officer.

3.4.11 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.11.1 TAB Field Acceptance Testing

During the field acceptance testing, verify, in the presence of the COTR, random selections of data (water, air quantities, air motion, sound level readings) recorded in the TAB Report. Points and areas for field acceptance testing are to be selected by the COTR. Measurement and test procedures are the same as approved for TAB work for the TAB Report.

Field acceptance testing includes verification of TAB Report data recorded for the following equipment groups:

Group 1: All chillers, boilers, return fans, computer room units, and air handling units (rooftop and central stations).

Group 2: 25 percent of the VAV terminal boxes and associated diffusers and registers.

Group 3: 25 percent of the supply diffusers, registers, grilles associated with constant volume air handling units.

Group 4: 25 percent of the return grilles, return registers, exhaust grilles and exhaust registers.

Group 5: 25 percent of the supply fans, exhaust fans, and pumps.

Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the COTR. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.

3.4.11.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR. Further, if any data on the TAB Report for a given field acceptance test group is out-of-tolerance, then field test data for one additional field test group as specified herein. Continue this increase field test work until out-of-tolerance data is no longer found. This additional field testing is over and above the original 25 percent of the reported data entries to be field tested.

If there are no more similar field test groups from which to choose, additional field testing from another, but different, type of field testing group must be tested.

3.4.11.3 Prerequisite for Approval

Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Contracting Officer approval of the TAB Report submitted.

3.5 MARKING OF SETTINGS

Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

3.6 MARKING OF TEST PORTS

The TAB team is to permanently and legibly mark and identify the location points of the duct test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

-- End of Section --

SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013; Errata 1-3 2013; Errata 4-6 2014; Errata 7 2015) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.2	(2007; Addendum B 2010) Energy Efficient Design of Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	(2014) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A580/A580M	(2014) Standard Specification for Stainless Steel Wire
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C1126	(2014) Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C1136	(2012) Standard Specification for

	Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1290	(2011) Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
ASTM C195	(2007; R 2013) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C450	(2008) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C533	(2013) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2014) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2012) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2014) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM C592	(2013) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C610	(2011) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C612	(2014) Mineral Fiber Block and Board Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C795	(2008; R 2013) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2014) Standard Specification for Adhesives for Duct Thermal Insulation

ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM E2231	(2014) Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E2336	(2014) Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2013) Standard Test Methods for Water Vapor Transmission of Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2758	(2014) Paper - Determination of Bursting Strength

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds	(1999) National Commercial & Industrial Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2015) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 96	(2014) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

TAPPI T403 OM	(2010) Bursting Strength of Paper

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-24179 (1969; Rev A; Am 2 1980; Notice 1 1987) Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-A-3316 (1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation

UNDERWRITERS LABORATORIES (UL)

UL 723 (2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials

UL 94 (2013; Reprint Sep 2014) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 SYSTEM DESCRIPTION

1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Field applied insulation materials required for use on Government-furnished items as listed in the SPECIAL CONTRACT REQUIREMENTS shall be furnished and installed by the Contractor.

1.2.2 Surface Burning Characteristics

Unless otherwise specified, insulation shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flame spread, and smoke developed indexes, shall be determined by ASTM E84 or UL 723. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Test specimens shall be prepared and mounted according to ASTM E2231. Insulation materials located exterior to the building perimeter are not required to be fire rated.

1.2.3 Recycled Materials

Provide thermal insulation containing recycled materials to the extent practicable, provided that the material meets all other requirements of this section. The minimum recycled material content of the following insulation are:

Rock Wool	75 percent slag of weight
Fiberglass	20-25 percent glass cullet by weight
Rigid Foam	9 percent recovered material

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

MICA Plates; G
Pipe Insulation Systems and Associated Accessories; G
Duct Insulation Systems and Associated Accessories; G
Equipment Insulation Systems and Associated Accessories; G

SD-03 Product Data

Pipe Insulation Systems; G
Duct Insulation Systems; G
Equipment Insulation Systems; G

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G
Duct Insulation Systems; G
Equipment Insulation Systems; G

1.4 QUALITY ASSURANCE

1.4.1 Installer Qualification

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered in the manufacturer's unopened containers. Materials delivered and placed in storage shall be provided with protection from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. Packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval shall have manufacturer's stamp or label attached giving the name of the manufacturer and brand, and a description of the material. Insulation packages and containers shall be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. The product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation shall be included. The product data must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. Materials furnished under this section shall be submitted together in a booklet. Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems which are located within, on, under, and adjacent to buildings; and for plumbing systems. Insulation shall be CFC and HCFC free.

2.2 MATERIALS

Provide insulation that meets or exceed the requirements of ASHRAE 90.1 - SI (ASHRAE 90.1 - IP) and ASHRAE 90.2. Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C795 requirements. Calcium silicate shall not be used on chilled or cold water systems. Materials shall be asbestos free and conform to the following: Flexible Elastomeric: Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive. Comply with ASTM C534/C534M, Type I, Grade 1, for tubular materials and Type II, Grade 1, for sheet materials. Provide product recognized under UL 94 and listed in FM APP GUIDE.

2.2.1 Adhesives

2.2.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to ASTM C916, Type I.

2.2.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with ASTM C195.

2.2.1.3 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. Lagging adhesives shall be nonflammable and fire-resistant and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Adhesive shall be MIL-A-3316, Class 1, pigmented white or red and be suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in strict accordance with the manufacturer's recommendations for pipe and duct insulation. Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Each material used shall be identified, by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Approved display sample sections shall remain on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

a. Pipe Insulation Display Sections: Display sample sections shall include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

b. Duct Insulation Display Sections: Display sample sections for rigid and flexible duct insulation used on the job. A temporary covering shall be used to enclose and protect display sections for duct insulation exposed to weather.

2.2.2 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 100 degrees C (212 degrees F). The dried adhesive shall be nonflammable and fire resistant. Natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation shall be used to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179, Type II, Class I. Provide product recognized under UL 94 and listed in FM APP GUIDE.

2.2.3 Caulking

ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.4 Corner Angles

2.2.4.1 General

Nominal 0.406 mm (0.016 inch) aluminum 25 by 25 mm (1 by 1 inch) with factory applied kraft backing. Aluminum shall be ASTM B209M (ASTM B209), Alloy 3003, 3105, or 5005.

2.2.4.2 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems. Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor).

2.2.5 Finishing Cement

ASTM C450: Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with ASTM C795.

2.2.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth, with 20X20 maximum mesh size, and glass tape shall have maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Tape shall be 100 mm (4 inch) wide rolls. Class 3 tape shall be 0.15 kg/square m (4.5 ounces/square yard). Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

Outward clinching type ASTM A167, Type 304 or 316 stainless steel.

2.2.8 Jackets

2.2.8.1 Aluminum Jackets

Aluminum jackets shall be corrugated, embossed or smooth sheet, 0.406 mm (0.016 inch) nominal thickness; ASTM B209M (ASTM B209), Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Corrugated aluminum jacket shall not be used outdoors. Aluminum jacket securing bands shall be Type 304 stainless steel, 0.396 mm (0.015 inch) thick, 13 mm (1/2 inch) wide for pipe under 300 mm (12 inch) diameter and 19 mm (3/4 inch) wide for pipe over 300 mm (12 inch) and larger diameter. Aluminum jacket circumferential seam bands shall be 50.8 by 0.406 mm (2 by 0.016 inch) aluminum matching jacket material. Bands for insulation below ground shall be 19 by 0.508 mm (3/4 by 0.020 inch) thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburgh or "Z" type longitudinal joint. When the "Z" joint is used, the bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

2.2.8.2 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, UV resistant rating or treatment and moderate chemical resistance with minimum thickness 0.762 mm (0.030 inch).

2.2.8.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive, greater than 3 plies standard grade, silver, white, black and embossed or greater than 8 ply (minimum 0.072 mm (2.9 mils) adhesive); with 0.0000 permeability when tested in accordance with ASTM E96/E96M; heavy duty, white or natural; and UV resistant. Flexible Elastomeric exterior foam with factory applied, UV Jacket made with a cold weather acrylic adhesive. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent WVT.

2.2.9 Vapor Retarder Required

ASTM C921, Type I, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where a minimum puncture resistance of 25 Beach units is acceptable. Minimum tensile strength, 6.1 N/mm (35 pounds/inch) width. ASTM C921, Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 3.5 N/mm (20 pounds/inch) width. Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials that require factory applied jackets are mineral fiber, cellular glass, polyisocyanurate, and phenolic foam. Insulation materials that do not require jacketing are flexible elastomerics. All non-metallic jackets shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.9.1 White Vapor Retarder All Service Jacket (ASJ)

Standard reinforced fire retardant jacket for use on hot/cold pipes, ducts, or equipment. Vapor retarder jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing.

2.2.9.2 Vapor Retarder/Vapor Barrier Mastic Coatings

a. The vapor barrier shall be self adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) greater than 3 plies standard grade, silver, white, black and embossed white jacket for use on hot/cold pipes. Less than 0.02 permeability when tested in accordance with ASTM E96/E96M. Meeting UL 723 or ASTM E84 flame and smoke requirements; UV resistant.

b. The vapor retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Color shall be white. The water vapor permeance of the compound shall be determined according to procedure B of ASTM E96/E96M utilizing apparatus described in ASTM E96/E96M. The coating shall be a nonflammable, fire resistant type. All other application and service properties shall be in accordance with ASTM C647.

2.2.9.3 Laminated Film Vapor Retarder

ASTM C1136, Type I, maximum moisture vapor transmission 0.02 perms, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where Type II, maximum moisture vapor transmission 0.02 perms, a minimum puncture resistance of 25 Beach units is acceptable. Vapor retarder shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flexible Elastomeric exterior foam with factory applied UV Jacket. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent WVT.

2.2.9.4 Vapor Barrier

The vapor barrier shall be greater than 3 ply self adhesive laminate -white vapor barrier jacket- superior performance (less than 0.0000 permeability when tested in accordance with ASTM E96/E96M). Vapor barrier shall meet UL 723 or ASTM E84 25 flame and 50 smoke requirements; and UV resistant. Minimum burst strength 1.3 MPa (185 psi) in accordance with TAPPI T403 OM and ISO 2758. Tensile strength 0.12 kg/m (68 lb/inch) width (PSTC-1000). Tape shall be as specified for laminated film vapor barrier above.

2.2.10 Vapor Retarder Not Required

ASTM C921, Type II, Class D, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable. Jacket shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.11 Wire

Soft annealed ASTM A580/A580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.12 Insulation Bands

Insulation bands shall be 13 mm (1/2 inch) wide; 26 gauge stainless steel.

2.2.13 Sealants

Sealants shall be chosen from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Sealants shall have a maximum moisture vapor transmission of 0.02 perms, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.3 PIPE INSULATION SYSTEMS

Insulation materials shall conform to Table 1. Insulation thickness shall be as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - SI(ASHRAE 90.1 - IP) and ASHRAE 90.2Pipe insulation materials shall be limited to those listed herein and shall meet the following requirements:

2.3.1 Aboveground Cold Pipeline (-34 to 16 deg. C (-30 to 60 deg. F))

Insulation for outdoor, indoor, exposed or concealed applications, shall be as follows:

a. Cellular Glass: ASTM C552, Type II, and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

b. Flexible Elastomeric Cellular Insulation: ASTM C534/C534M, Grade 1, Type I or II. Type II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation.

c. Phenolic Insulation: ASTM C1126, Type III. Phenolic insulations shall comply with ASTM C795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

f. Mineral Fiber Insulation with Integral Wicking Material (MFIWM): ASTM C547. Install in accordance with manufacturer's instructions.

2.3.2 Aboveground Hot Pipeline (Above 16 deg. C (60 deg. F))

Insulation for outdoor, indoor, exposed or concealed applications shall meet the following requirements. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

a. Mineral Fiber: ASTM C547, Types I, II or III, supply the insulation with manufacturer's recommended factory-applied jacket.

b. Calcium Silicate: ASTM C533, Type I indoor only, or outdoors above 121 degrees C (250 degrees F) pipe temperature. Supply insulation with the manufacturer's recommended factory-applied jacket/vapor barrier.

c. Cellular Glass: ASTM C552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

d. Flexible Elastomeric Cellular Insulation: ASTM C534/C534M, Grade 1, Type I or II to 105 degrees C (220 degrees F) service.

e. Phenolic Insulation: ASTM C1126 Type III to 121 degrees C (250 degrees F) service shall comply with ASTM C795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

f. Perlite Insulation: ASTM C610

2.3.3 Above Ground Dual Temperature Pipeline

Selection of insulation for use over a dual temperature pipeline system (Outdoors, Indoor - Exposed or Concealed) shall be in accordance with the most limiting/restrictive case. Find an allowable material from paragraph PIPE INSULATION MATERIALS and determine the required thickness from the most restrictive case. Use the thickness listed in paragraphs INSULATION THICKNESS for cold & hot pipe applications.

2.3.4 Below-ground Pipeline Insulation

For below-ground pipeline insulation the following requirements shall be met.

2.3.4.1 Cellular Glass

ASTM C552, type II.

2.4 DUCT INSULATION SYSTEMS

2.4.1 Duct Insulation

Provide factory-applied cellular glass polyisocyanurate or phenolic foam or elastomeric insulation. Provide factory applied elastomeric closed cell or phenolic foam insulation according to manufacturer's recommendations for insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier, with identification of installed thermal resistance (R) value and out-of-package R value.

2.4.1.1 Rigid Insulation

Rigid mineral fiber in accordance with ASTM C612, Class 2 (maximum surface temperature 204 degrees C (400 degrees F)), 48 kg/m3 (3 pcf) average, 38 mm (1-1/2 inch) thick, Type IA, IB, II, III, and IV. Alternately, minimum thickness may be calculated in accordance with ASHRAE 90.2 and ASHRAE 90.1 - SI(ASHRAE 90.1 - IP).

2.4.1.2 Blanket Insulation

Blanket flexible mineral fiber insulation conforming to ASTM C585, Type 1, Class B-3, 12 kg/m3 (3/4 pcf) nominal, 50 mm (2.0 inches) thick or Type II up to 121 degrees C (250 degrees F). Also ASTM C1290 Type III may be used. Alternately, minimum thickness may be calculated in accordance with ASHRAE 90.2 and ASHRAE 90.1 - SI(ASHRAE 90.1 - IP).

2.4.2 Kitchen Exhaust Ductwork Insulation

Insulation thickness shall be a minimum of 50 mm (2 inches), blocks or boards, either mineral fiber conforming to ASTM C612, Class 5, 320 kg/m3 (20 pcf) average or calcium silicate conforming to ASTM C533, Type II. Provide vapor barrier for outside air connection to kitchen exhaust hood. The enclosure materials and the grease duct enclosure systems shall meet testing requirements of ASTM E2336 for noncombustibility, fire resistance, durability, internal fire, and fire-engulfment with a through-penetration fire stop.

2.4.3 Acoustical Duct Lining

2.4.3.1 General

For ductwork indicated or specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM to be acoustically lined, provide external insulation in accordance with this specification section and in addition to the acoustical duct lining. Do not use acoustical lining in place of duct wrap or rigid board insulation (insulation on the exterior of the duct).

2.4.3.2 Duct Liner

Flexible Elastomeric Acoustical and Conformable Duct Liner: Materials: Flexible Elastomeric Thermal, Acoustical and Conformable Insulation Compliance with ASTM C534/C534M Grade 1, Type II or NFPA 90A or NFPA 90B.

2.4.4 Duct Insulation Jackets

2.4.4.1 All-Purpose Jacket

Provide insulation with insulation manufacturer's standard reinforced fire-retardant jacket with or without integral vapor barrier as required by the service. In exposed locations, provide jacket with a white surface suitable for field painting.

2.4.4.2 Metal Jackets

a. Aluminum Jackets: ASTM B209M (ASTM B209), Temper H14, minimum thickness of 27 gauge (0.41 mm (0.016 inch)), with factory-applied polyethylene and kraft paper moisture barrier on inside surface.

Provide smooth surface jackets for jacket outside dimension 200 mm (8 inches) and larger. Provide corrugated surface jackets for jacket outside dimension 200 mm (8 inches) and larger. Provide stainless steel bands, minimum width of 13 mm (1/2 inch).

b. Stainless Steel Jackets: ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.25 mm (0.010 inch)), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 13 mm (1/2 inch).

2.4.4.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 0.072 mm (2.9 mils) adhesive), heavy duty white or natural).

2.4.5 Weatherproof Duct Insulation

Provide ASTM C552, cellular glass thermal insulation, ASTM C534/C534M Grade 1, Type II, flexible elastomeric cellular insulation, and weatherproofing as specified in manufacturer's instruction. Multi-ply, Polymeric Blend Laminate Jacketing: Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent WVT.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 4 and 5. In outside locations, provide insulation 13 mm (1/2 inch) thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems. The instructions must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs entitled: Pipe Insulation Systems; and Duct Insulation Systems.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Insulation shall only be applied to unheated and uncooled piping and equipment. Flexible elastomeric cellular insulation shall not be compressed at joists, studs, columns, ducts, hangers, etc. The insulation shall not pull apart after a one hour period; any insulation found to pull apart after one hour, shall be replaced.

3.1.1 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests or tests and heat tracing specified in other sections of this specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the jobsite. Joints shall be staggered on multi layer insulation. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces. Insulation, jacketing and accessories shall be installed in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.2 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING. The protection of ducts at point of passage through firewalls must be in accordance with NFPA 90A and/or NFPA 90B. All other penetrations, such as piping, conduit, and wiring, through firewalls must be protected with a material or system of the same hourly rating that is listed by UL, FM, or a NRTL.

3.1.3 Painting and Finishing

Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.4 Installation of Flexible Elastomeric Cellular Insulation

Flexible elastomeric cellular insulation shall be installed with seams and joints sealed with rubberized contact adhesive. Flexible elastomeric cellular insulation shall not be used on surfaces greater than 105 degrees C (220 degrees F). Seams shall be staggered when applying multiple layers of insulation. Insulation exposed to weather and not shown to have jacketing shall be protected with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured. A brush coating of adhesive shall be applied to both butt ends to be joined and to both slit surfaces to be sealed. The adhesive shall be allowed to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one hour after application. Insulation that can be pulled apart one hour after installation shall be replaced.

3.1.5 Welding

No welding shall be done on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.6 Pipes/Ducts/Equipment which Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items, as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

3.2.1 Pipe Insulation

3.2.1.1 General

Pipe insulation shall be installed on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified otherwise. Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used. Pipe insulation shall be omitted on the following:

a. Pipe used solely for fire protection.

b. Chromium plated pipe to plumbing fixtures. However, fixtures for use by the physically handicapped shall have the hot water supply and drain, including the trap, insulated where exposed.

c. Sanitary drain lines.

d. Air chambers.

e. Adjacent insulation.

f. ASME stamps.

g. Access plates of fan housings.

h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

a. Pipe insulation shall be continuous through the sleeve.

b. An aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder shall be provided over the insulation wherever penetrations require sealing.

c. Where pipes penetrate interior walls, the aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) less than 0.0000 permeability, greater than 3 plies standard grade, silver, white, black and embossed shall extend 50 mm (2 inches) beyond either side of the wall and shall be secured on each end with a band.

d. Where penetrating floors, the aluminum jacket shall extend from a point below the backup material to a point 250 mm (10 inches) above the floor with one band at the floor and one not more than 25 mm (1 inch) from the end of the aluminum jacket.

e. Where penetrating waterproofed floors, the aluminum jacket shall extend from below the backup material to a point 50 mm (2 inches) above the flashing with a band 25 mm (1 inch) from the end of the aluminum jacket.

f. Where penetrating exterior walls, the aluminum jacket required for pipe exposed to weather shall continue through the sleeve to a point 50 mm (2 inches) beyond the interior surface of the wall.

g. Where penetrating roofs, pipe shall be insulated as required for interior service to a point flush with the top of the flashing and sealed with vapor retarder coating. The insulation for exterior application shall butt tightly to the top of flashing and interior insulation. The exterior aluminum jacket shall extend 50 mm (2 inches) down beyond the end of the insulation to form a counter flashing. The flashing and counter flashing shall be sealed underneath with caulking.

h. For hot water pipes supplying lavatories or other similar heated service that requires insulation, the insulation shall be terminated on the backside of the finished wall. The insulation termination shall be protected with two coats of vapor barrier coating with a minimum total thickness of 2.0 mm (1/16 inch) applied with glass tape embedded between coats (if applicable). The coating shall extend out onto the insulation 50 mm (2 inches) and shall seal the end of the insulation. Glass tape seams shall overlap 25 mm (1 inch). The annular space between the pipe and wall penetration shall be caulked with approved fire stop material. The pipe and wall penetration shall be covered with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration at least 10 mm (3/8 inches).

i. For domestic cold water pipes supplying lavatories or other similar cooling service that requires insulation, the insulation shall be terminated on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). The insulation shall be protected with two coats of vapor barrier coating with a minimum total thickness of 2 mm (1/16 inch). The coating shall extend out onto the insulation 50 mm (2 inches) and shall seal the end of the insulation. The annular space between the outer surface of the pipe insulation and the wall penetration shall be caulked with an approved fire stop material having vapor retarder properties. The pipe and wall penetration shall be covered with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration by at least 10 mm (3/8 inches).

3.2.1.3 Pipes Passing Through Hangers

a. Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes 50 mm (2 inches) and smaller shall be supported on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-69. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, insulation inserts as specified below for piping larger than 50 mm (2 inches) shall be installed, or factory insulated hangers (designed with a load bearing core) can be used.

b. Horizontal pipes larger than 50 mm (2 inches) at 16 degrees C (60 degrees F) and above shall be supported on hangers in accordance with MSS SP-69, and Section 22 00 00 PLUMBING, GENERAL PURPOSE.

c. Horizontal pipes larger than 50 mm (2 inches) and below 16 degrees C

(60 degrees F) shall be supported on hangers with the addition of a Type 40 protection shield in accordance with MSS SP-69. An insulation insert of cellular glass, prefabricated insulation pipe hangers, perlite above 27 degrees C (80 degrees F)), or the necessary strength polyisocyanurate shall be installed above each shield. The insert shall cover not less than the bottom 180-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 50 mm (2 inches) on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 25 mm (1 inch), wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert.

d. Vertical pipes shall be supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-69 covering the 360-degree arc of the insulation. An insulation insert of cellular glass or calcium silicate shall be installed between each shield and the pipe. The insert shall cover the 360-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 50 mm (2 inches) on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 25 mm (1 inch), wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert. The vertical weight of the pipe shall be supported with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 9 m (30 feet), the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe that are directly clamped to the pipe, penetrating the pipe insulation. These hangers shall be insulated and the insulation jacket sealed as indicated herein for anchors in a similar service.

e. Inserts shall be covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, shall overlap the adjoining pipe jacket 38 mm (1-1/2 inches), and shall be sealed as required for the pipe jacket. The jacket material used to cover inserts in flexible elastomeric cellular insulation shall conform to ASTM C1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Flexible elastomeric cellular pipe insulation shall be tubular form for pipe sizes 150 mm (6 inches) and less. Grade 1, Type II sheet insulation used on pipes larger than 150 mm (6 inches) shall not be stretched around the pipe. On pipes larger than 300 mm (12 inches), the insulation shall be adhered directly to the pipe on the lower 1/3 of the pipe. Seams shall be staggered when applying multiple layers of insulation. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation.

3.2.1.5 Pipes in high abuse areas.

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, welded PVC, stainless steel, or aluminum jackets shall be utilized. Pipe insulation to the 1.8 m (6 foot) level shall be protected.

3.2.1.6 Pipe Insulation Material and Thickness

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Chilled Water (Supply & Return, Dual Temperature Piping, 4.44 C (40 F) nominal)					
	Cellular Glass	ASTM C552	II	2	Yes
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes
	Mineral Fiber with Wicking Material Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.	ASTM C547	I		Yes
Heating Hot Water Supply & Return, Heated Oil (Max 121 C (250 F))					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	II	2	No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No

TABLE 1

Insulation Material for Piping

Service					
	Material	Specification	Type	Class	VR/VB Req'd
Hot Domestic Water Supply & Recirculating Piping (Max 93 C (200 F))					
	Mineral Fiber	ASTM C547	I	1	No
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
Refrigerant Suction Piping (1.67 degrees C (35 degrees F) nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Cellular Glass	ASTM C552	II	1	Yes
Compressed Air Discharge, Steam and Condensate Return (94 to 121 Degrees C (201 to 250 Degrees F))					
	Cellular Glass	ASTM C552	II		No
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Cellular Glass	ASTM C552	III		Yes

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Condensate Drain Located Inside Building					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Medium Temperature Hot Water, Steam and Condensate (122 to 176 Degrees C (251 to 350 Degrees F))					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	I or II		No
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
High Temperature Hot Water & Steam (177 to 371 Degrees C (351 to 700 Degrees F))					
	Mineral Fiber	ASTM C547	I	2	No
	Calcium Silicate	ASTM C533	I		No
	Perlite	ASTM C610			No
	Cellular Glass	ASTM C552			No
Brine Systems Cryogenics (-34 to -18 Degrees C (-30 to 0 Degrees F))					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Brine Systems Cryogenics (-18 to 1.11 Degrees C (0 to 34 Degrees F))					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No

TABLE 1

Insulation Material for Piping

Service					
	Material	Specification	Type	Class	VR/VB Req'd
Note: VR/VB = Vapor Retarder/Vapor Barrier					

TABLE 2

Piping Insulation Thickness (mm (inch))
For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (mm) (inch)				
		<25 (<1)	25-<40 (1-<1.5)	40-<100 (1.5-<4)	100-<200 (4-<8)	> or = 200 (>8)
Chilled Water (Supply & Return, Dual Temperature Piping, 4.44 Degrees C (40 Degrees F) nominal)						
	Cellular Glass	40 (1.5)	50 (2)	50 (2)	65 (2.5)	80 (3)
	Mineral Fiber with Wicking Material	25 (1)	40 (1.5)	40 (1.5)	50 (2)	50 (2)
	Flexible Elastomeric Cellular	25 (1)		25 (1)	N/A	N/A
Chilled Water (Supply & Return, Dual Temperature Piping, 4.44 Degrees C (40 Degrees F) nominal)						
	Cellular Glass	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)	50 (2)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
	Mineral Fiber with Wicking Material	25 (1)	40 (1.5)	40 (1.5)	50 (2)	50 (2)

TABLE 2

Piping Insulation Thickness (mm (inch))
For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (mm) (inch)				
		<25 (<1)	25-<40 (1-<1.5)	40-<100 (1.5-<4)	100-<200 (4-<8)	> or = 200 (>8)
Heating Hot Water Supply & Return, Heated Oil (Max 121 C (250 F))						
	Mineral Fiber	40 (1.5)	40 (1.5)	50 (2)	50 (2)	50 (2)
	Calcium Silicate	65 (2.5)	65 (2.5)	80 (3)	80 (3)	80 (3)
	Cellular Glass	50 (2)	65 (2.5)	75 (3)	80 (3)	80 (3)
	Perlite	65 (2.5)	65 (2.5)	80 (3)	80 (3)	80 (3)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25(1)	N/A	N/A
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping						
	Cellular Glass	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
Hot Domestic Water Supply & Recirculating Piping (Max 93 C (200 F))						
	Mineral Fiber	25 (1)	25 (1)	25 (1)	40 (1.5)	40 (1.5)
	Cellular Glass	40 (1.5)	40 (1.5)	40 (1.5)	50 (2)	50 (2)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
Refrigerant Suction Piping (1.67 degrees C(35 degrees F) nominal)						

TABLE 2

Piping Insulation Thickness (mm (inch))

For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service					
Material	Tube And Pipe Size (mm) (inch)				
	<25 (<1)	25-<40 (1-<1.5)	40-<100 (1.5-<4)	100-<200 (4-<8)	> or = 200 (>8)
Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
Cellular Glass	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)
Compressed Air Discharge, Steam and Condensate Return (94 to 121 Degrees C(201 to 250 Degrees F)					
Mineral Fiber	40 (1.5)	40 (1.5)	50 (2)	50 (2)	50 (2)
	40 (1.5) *	50 (2)*	65 (2.5)*	80 (3)*	90 (3.5)*
Calcium Silicate	65 (2.5)	80 (3)	100 (4)	100 (4)	115 (4.5)
Cellular Glass	50 (2)	65 (2.5)	80 (3)	80 (3)	80 (3)
Perlite	65 (2.5)	80 (3)	100 (4)	100 (4)	115 (4.5)
Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel					
Flexible Elastomeric Cellular	13 (0.5)	13 (0.5)	13 (0.5)	13 (0.5)	13 (0.5)
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)					
Cellular Glass	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)
Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A

TABLE 2

Piping Insulation Thickness (mm (inch))
For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (mm) (inch)				
		<25 (<1)	25-<40 (1-<1.5)	40-<100 (1.5-<4)	100-<200 (4-<8)	> or = 200 (>8)
	Faced Phenolic Foam	25 (1)	25 (1)	25 (1)	25 (1)	25 (1)
Condensate Drain Located Inside Building						
	Cellular Glass	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)	40 (1.5)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
Medium Temperature Hot Water, Steam and Condensate (122 to 176 Degrees C(251 to 350 Degrees F))						
	Mineral Fiber	40 (1.5)	80 (3)	80 (3)	100 (4)	100 (4)
		65 (2.5) *	80 (3)*	90 (3.5)*		
	Calcium Silicate	65 (2.5)	90 (3.5)	115 (4.5)	115 (4.5)	125 (5)
	Perlite	65 (2.5)	90 (3.5)	115 (4.5)	115 (4.5)	125 (5)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
High Temperature Hot Water & Steam (177 to 371 Degrees C(351 to 700 Degrees F))						
	Mineral Fiber	65 (2.5)	80 (3)	80 (3)	100 (4)	100 (4)
	Calcium Silicate	100 (4)	115 (4.5)	150 (6)	150 (6)	150 (6)
	Perlite	100 (4)	115 (4.5)	150 (6)	150 (6)	150 (6)

TABLE 2						
Piping Insulation Thickness (mm (inch)) For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (mm) (inch)				
		<25 (<1)	25-<40 (1-<1.5)	40-<100 (1.5-<4)	100-<200 (4-<8)	> or = 200 (>8)
Brine Systems Cryogenics (-34 to -18 Degrees C(-30 to 0 Degrees F))						
	Cellular Glass	65 (2.5)	65 (2.5)	80 (3)	80 (3)	90 (3.5)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	N/A	N/A	N/A
Brine Systems Cryogenics (-18 to 1.11 Degrees C(0 to 34 Degrees F))						
	Cellular Glass	50 (2)	50 (2)	50 (2)	65 (2.5)	80 (3)
	Flexible Elastomeric Cellular	25 (1)	25 (1)	25 (1)	N/A	N/A
			25 1			

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 34 to plus 16 degrees C (minus 30 to plus 60 degrees F), shall be insulated in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Make-up water.

b. Horizontal and vertical portions of interior roof drains.

c. Refrigerant suction lines.

d. Chilled water.

e. Dual temperature water, i.e. HVAC hot/chilled water.

f. Air conditioner condensate drains.

g. Brine system cryogenics

h. Exposed lavatory drains and domestic water lines serving plumbing fixtures for handicap persons.

i. Domestic cold and chilled drinking water.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using Table 2.

3.2.2.2 Factory or Field applied Jacket

Insulation shall be covered with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, sliver, white, black and embossed for use with Mineral Fiber, Cellular Glass, Phenolic Foam, and Polyisocyanurate Foam Insulated Pipe. Insulation inside the building, to be protected with an aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, shall be installed as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, aluminum jackets or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) product, less than 0.0000 permeability, standard grade, embossed silver, white & black, shall be provided for pipe insulation to the 1.8 m (6 ft) level.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

a. Insulation shall be applied to the pipe with joints tightly butted. All butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

b. Longitudinal laps of the jacket material shall overlap not less than 38 mm (1-1/2 inches). Butt strips 75 mm (3 inches) wide shall be provided for circumferential joints.

c. Laps and butt strips shall be secured with adhesive and stapled on 100 mm (4 inch) centers if not factory self-sealing. If staples are used, they shall be sealed in accordance with item "e." below. Note that staples are not required with cellular glass systems.

d. Factory self-sealing lap systems may be used when the ambient temperature is between 4 and 50 degrees C (40 and 120 degrees)F during installation. The lap system shall be installed in accordance with manufacturer's recommendations. Stapler shall be used only if specifically recommended by the manufacturer. Where gaps occur, the section shall be replaced or the gap repaired by applying adhesive under the lap and then stapling.

e. All Staples, including those used to repair factory self-seal lap systems, shall be coated with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. All seams, except those on factory self-seal systems shall be coated with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

f. Breaks and punctures in the jacket material shall be patched by wrapping a strip of jacket material around the pipe and securing it with adhesive, stapling, and coating with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. The patch shall extend not less than 38 mm (1-1/2 inches) past the break.

g. At penetrations such as thermometers, the voids in the insulation shall be filled and sealed with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

h. Installation of flexible elastomeric cellular pipe insulation shall be by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. All seams and butt joints shall be secured and sealed with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Insulation shall be pushed on the pipe, never pulled. Stretching of insulation may result in open seams and joints. All edges shall be clean cut. Rough or jagged edges of the insulation shall not be permitted. Proper tools such as sharp knives shall be used. Grade 1, Type II sheet insulation when used on pipe larger than 150 mm (6 inches) shall not be stretched around the pipe. On pipes larger than 300 mm (12 inches), adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 50 mm (2 inches) or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow'. Submit a booklet containing completed MICA Insulation Stds plates detailing each insulating system for each pipe, duct, or equipment insulating system, after approval of materials and prior to applying insulation.

(1) The MICA plates shall detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. The MICA plates shall present all variations of insulation systems including locations, materials, vapor-proofing, jackets and insulation accessories.

(2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, the detail drawings shall be technically equivalent to the edited MICA Plate submittal.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of 2 mm (1/16 inch), applied with glass tape embedded between coats. Tape seams shall overlap 25 mm (1 inch). The coating shall extend out onto the adjoining pipe insulation 50 mm (2 inches). Fabricated insulation with a factory vapor retarder jacket shall be protected with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of 2 mm (1/16 inch) and with a 50 mm (2 inch) wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapor retarder coating and a 100 mm (4 inch) wide ASJ tape which matches the jacket of the pipe insulation.

d. Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 150 mm (6 inches) from the insulation surface.

e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

All hot pipe lines above 16 degrees C (60 degrees F), except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, shall be insulated in accordance with Table 2. This includes but is not limited to the following:

a. Domestic hot water supply & re-circulating system.

b. Steam.

c. Condensate & compressed air discharge.

d. Hot water heating.

e. Heated oil.

f. Water defrost lines in refrigerated rooms.

Insulation shall be covered, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

a. General. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant. Insulation shall be marked showing the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

b. Precut or Preformed. Precut or preformed insulation shall be placed around all fittings and accessories. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity.

c. Rigid Preformed. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 50 mm (2 inches) or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow".

3.2.4 Piping Exposed to Weather

Piping exposed to weather shall be insulated and jacketed as specified for the applicable service inside the building. After this procedure, a laminated self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket or PVC jacket shall be applied. PVC jacketing requires no factory-applied jacket beneath it, however an all service jacket shall be applied if factory applied jacketing is not furnished. Flexible elastomeric cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. The jacket shall overlap not less than 50 mm (2 inches) at longitudinal and circumferential joints and shall be secured with bands at not more than 300 mm (12 inch) centers. Longitudinal joints shall be overlapped down to shed water and located at 4 or 8 o'clock positions. Joints on piping 16 degrees C (60 degrees F) and below shall be sealed with caulking while overlapping to prevent moisture penetration. Where jacketing on piping 16 degrees C (60 degrees F) and below abuts an un-insulated surface, joints shall be caulked to prevent moisture penetration. Joints on piping above 16 degrees C (60 degrees F) shall be sealed with a moisture retarder.

3.2.4.2 Insulation for Fittings

Flanges, unions, valves, fittings, and accessories shall be insulated and finished as specified for the applicable service. Two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air) recommended by the insulation manufacturer shall be applied with glass tape embedded between coats. Tape overlaps shall be not less than 25 mm (1 inch) and the adjoining aluminum jacket not less than 50 mm (2 inches). Factory preformed aluminum jackets may be used in lieu of the above. Molded PVC fitting covers shall be provided when PVC jackets are used for straight runs of pipe. PVC fitting covers shall have adhesive welded joints and shall be weatherproof laminated self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed, and UV resistant.

3.2.4.3 PVC Jacket

PVC jacket shall be ultraviolet resistant and adhesive welded weather tight with manufacturer's recommended adhesive. Installation shall include provision for thermal expansion.

3.2.5 Below Ground Pipe Insulation

Below ground pipes shall be insulated in accordance with Table 2, except as precluded in subparagraph Pipe Insulation in PART 3. This includes, but is not limited to the following:

a. Heated oil.

b. Domestic hot water.

c. Heating hot water.

d. Dual temperature water.

e. Steam.

f. Condensate.

3.2.5.1 Type of Insulation

Below ground pipe shall be insulated with Cellular Glass insulation, or with Polyisocyanurate insulation, in accordance with manufacturer's instructions for application with thickness as determined from Table 2 (whichever is the most restrictive).

3.2.5.2 Installation of Below ground Pipe Insulation

a. Bore surfaces of the insulation shall be coated with a thin coat of gypsum cement of a type recommended by the insulation manufacturer. Coating thickness shall be sufficient to fill surface cells of insulation. Mastic type materials shall not be used for this coating. Note that unless this is for a cyclic application (i.e., one that fluctuates between high and low temperature on a daily process basis) there is no need to bore coat the material.

b. Stainless steel bands, 19 mm (3/4 inch) wide by 0.508 mm (0.020 inch) thick shall be used to secure insulation in place. A minimum of two bands per section of insulation shall be applied. As an alternate, fiberglass reinforced tape may be used to secure insulation on piping up to 300 mm (12 inches) in diameter. A minimum of two bands per section of insulation shall be applied.

c. Insulation shall terminate at anchor blocks but shall be continuous through sleeves and manholes.

d. At point of entry to buildings, underground insulation shall be terminated 50 mm (2 inches) inside the wall or floor, shall butt tightly against the aboveground insulation and the butt joint shall be sealed with high temperature silicone sealant and covered with fibrous glass tape.

e. Provision for expansion and contraction of the insulation system shall be made in accordance with the insulation manufacturer's recommendations.

f. Flanges, couplings, valves, and fittings shall be insulated with factory pre-molded, prefabricated, or field-fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Insulation sections shall be secured as recommended by the manufacturer.

g. Insulation, including fittings, shall be finished with three coats of asphaltic mastic, with 6 by 5.5 mesh synthetic reinforcing fabric embedded between coats. Fabric shall be overlapped a minimum of 50 mm (2 inches) at joints. Total film thickness shall be a minimum of 4.7 mm (3/16 inch). As an alternate, a prefabricated bituminous laminated jacket, reinforced with internal reinforcement mesh, shall be applied to the insulation. Jacketing material and application procedures shall match manufacturer's written instructions. Vapor barrier - less than 0.0000 permeability self adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) jacket greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 0.072 (2.9 mils) adhesive), heavy duty, white or natural). Application procedures shall match the manufacturer's written instructions.

h. At termination points, other than building entrances, the mastic and cloth or tape shall cover the ends of insulation and extend 50 mm (2 inches) along the bare pipe.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

Except for oven hood exhaust duct insulation, corner angles shall be installed on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. Duct insulation shall be omitted on exposed supply and return ducts in air conditioned spaces where the difference between supply air temperature and room air temperature is less than 9 degrees C (15 degrees F) unless otherwise shown. Air conditioned spaces shall be defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Thickness

Duct insulation thickness shall be in accordance with Table 4.

Table 4 - Minimum Duct Insulation (mm) (inches)

Cold Air Ducts	50(2.0)
Relief Ducts	40(1.5)
Fresh Air Intake Ducts	40(1.5)
Warm Air Ducts	50(2.0)
Relief Ducts	40(1.5)
Fresh Air Intake Ducts	40(1.5)

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Insulation and vapor retarder/vapor barrier shall be provided for the following cold air ducts and associated equipment.

a. Supply ducts.

b. Return air ducts.

c. Relief ducts.

d. Flexible run-outs (field-insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes (field-insulated).

l. Supply fans (field-insulated).

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Combustion air intake ducts.

Insulation for rectangular ducts shall be flexible type where concealed, minimum density 12 kg/cubic m (3/4 pcf), and rigid type where exposed, minimum density 48 kg/cubic m (3 pcf). Insulation for both concealed or exposed round/oval ducts shall be flexible type, minimum density 12 kg/cubic m (3/4 pcf) or a semi rigid board, minimum density 48 kg/cubic m (3 pcf), formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts shall be provided with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified, the total field applied dry film thickness shall be approximately 2 mm (1/16 inch). Insulation on all concealed duct shall be provided with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Duct insulation shall be continuous through sleeves and prepared openings except firewall penetrations. Duct insulation terminating at fire dampers, shall be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Duct insulation and vapor retarder/vapor barrier shall cover the collar, neck, and any un-insulated surfaces of diffusers, registers and grills. Vapor retarder/vapor barrier materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.3.2.1 Installation on Concealed Duct

a. For rectangular, oval or round ducts, flexible insulation shall be attached by applying adhesive around the entire perimeter of the duct in 150 mm (6 inch) wide strips on 300 mm (12 inch) centers.

b. For rectangular and oval ducts, 600 mm (24 inches) and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 400 mm (16 inch) centers and not more than 400 mm (16 inches) from duct corners.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 400 mm (16 inch) centers and not more than 400 mm (16 inches) from duct corners.

d. Insulation shall be impaled on the mechanical fasteners (self stick pins) where used and shall be pressed thoroughly into the adhesive. Care shall be taken to ensure vapor retarder/vapor barrier jacket joints overlap 50 mm (2 inches). The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type duct hangers.

e. Where mechanical fasteners are used, self-locking washers shall be installed and the pin trimmed and bent over.

f. Jacket overlaps shall be secured with staples and tape as necessary to ensure a secure seal. Staples, tape and seams shall be coated with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 0.05 mm (2 mils) adhesive, 0.075 (3 mils) embossed) - less than 0.0000 perm adhesive tape.

g. Breaks in the jacket material shall be covered with patches of the same material as the vapor retarder jacket. The patches shall extend not less than 50 mm (2 inches) beyond the break or penetration in all directions and shall be secured with tape and staples. Staples and tape joints shall be sealed with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) - less than 0.0000 perm adhesive tape.

h. At jacket penetrations such as hangers, thermometers, and damper operating rods, voids in the insulation shall be filled and the penetration sealed with a brush coat of vapor retarder coating or PVDC adhesive tape greater than 3 ply laminate (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) - less than 0.0000 perm adhesive tape.

i. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating.. The coating shall overlap the adjoining insulation and un-insulated surface 50 mm (2 inches). Pin puncture coatings shall extend 50 mm (2 inches) from the puncture in all directions.

j. Where insulation standoff brackets occur, insulation shall be extended under the bracket and the jacket terminated at the bracket.

3.3.2.2 Installation on Exposed Duct Work

a. For rectangular ducts, rigid insulation shall be secured to the duct by mechanical fasteners on all four sides of the duct, spaced not more than 300 mm (12 inches) apart and not more than 75 mm (3 inches) from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 300 mm (12 inches) and larger. One row shall be provided for each side of duct less than 300 mm (12 inches). Mechanical fasteners shall be as corrosion resistant as G60 coated galvanized steel, and shall indefinitely sustain a 22.7 kg (50 lb) tensile dead load test perpendicular to the duct wall.

b. Duct insulation shall be formed with minimum jacket seams. Each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over. Vapor retarder/barrier jacket shall be continuous across seams, reinforcing, and projections. When height of projections is greater than the insulation thickness, insulation and jacket shall be carried over. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and the pin trimmed and bent over.

d. Joints in the insulation jacket shall be sealed with a 100 mm (4 inch) wide strip of tape. Tape seams shall be sealed with a brush coat of vapor retarder coating.

e. Breaks and ribs or standing seam penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 50 mm (2 inches) beyond the break or penetration and shall be secured with tape and stapled. Staples and joints shall be sealed with a brush coat of vapor retarder coating.

f. At jacket penetrations such as hangers, thermometers, and damper operating rods, the voids in the insulation shall be filled and the penetrations sealed with a brush coat of vapor retarder coating.

g. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish. The coating shall overlap the adjoining insulation and un-insulated surface 50 mm (2 inches). Pin puncture coatings shall extend 50 mm (2 inches) from the puncture in all directions.

h. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation with minimum density of 12 kg per cubic meter (3/4 pcf), attached as in accordance with MICA standards.

3.3.3 Insulation for Warm Air Duct

Insulation and vapor barrier shall be provided for the following warm air ducts and associated equipment:.

a. Supply ducts.

b. Return air ducts.

c. Relief air ducts

d. Flexible run-outs (field insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil-headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes.

l. Supply fans.

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

Insulation for rectangular ducts shall be flexible type where concealed, and rigid type where exposed. Insulation on exposed ducts shall be provided with a white, paint-able, factory-applied Type II jacket, or finished with adhesive finish. Flexible type insulation shall be used for round ducts, with a factory-applied Type II jacket. Insulation on concealed duct shall be provided with a factory-applied Type II jacket. Adhesive finish where indicated to be used shall be accomplished by applying two coats of adhesive with a layer of glass cloth embedded between the coats. The total dry film thickness shall be approximately 2.0 mm (1/16 inch). Duct insulation shall be continuous through sleeves and prepared openings. Duct insulation shall terminate at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

a. For rectangular, oval and round ducts, insulation shall be attached by applying adhesive around the entire perimeter of the duct in 150 mm (6 inch) wide strips on 300 mm (12 inch) centers.

b. For rectangular and oval ducts 600 mm (24 inches) and larger, insulation shall be secured to the bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 450 mm (18 inch) centers and not more than 450 mm (18 inches) from duct corner.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 450 mm (18 inch) centers and not more than 450 mm (18 inches) from duct corners.

d. The insulation shall be impaled on the mechanical fasteners where used. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type hangers.

e. Self-locking washers shall be installed where mechanical fasteners are used and the pin trimmed and bent over.

f. Insulation jacket shall overlap not less than 50 mm (2 inches) at joints and the lap shall be secured and stapled on 100 mm (4 inch) centers.

3.3.3.2 Installation on Exposed Duct

a. For rectangular ducts, the rigid insulation shall be secured to the duct by the use of mechanical fasteners on all four sides of the duct, spaced not more than 400 mm (16 inches) apart and not more than 150 mm (6 inches) from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 300 mm (12 inches) and larger and a minimum of one row for each side of duct less than 300 mm (12 inches).

b. Duct insulation with factory-applied jacket shall be formed with minimum jacket seams, and each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over the projection. Jacket shall be continuous across seams, reinforcing, and projections. Where the height of projections is greater than the insulation thickness, insulation and jacket shall be carried over the projection.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and pin trimmed and bent over.

d. Joints on jacketed insulation shall be sealed with a 100 mm (4 inch) wide strip of tape and brushed with vapor retarder coating.

e. Breaks and penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 50 mm (2 inches) beyond the break or penetration and shall be secured with adhesive and stapled.

f. Insulation terminations and pin punctures shall be sealed with tape and brushed with vapor retarder coating.

g. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation, minimum density of 12 kg per cubic meter (3/4 pcf) attached by staples spaced not more than 400 mm (16 inches) and not more than 150 mm (6 inches) from the degrees of joints. Joints shall be sealed in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 16 degrees C (60 degrees F), ducts shall be insulated as specified for cold air duct.

3.3.5 Insulation for Evaporative Cooling Duct

Evaporative cooling supply duct located in spaces not evaporatively cooled, shall be insulated. Material and installation requirements shall be as specified for duct insulation for warm air duct.

3.3.6 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, breaks in the insulation and jacket shall be repaired in accordance with the applicable section of this specification for the type of duct insulation to be repaired.

3.3.7 Duct Exposed to Weather

3.3.7.1 Installation

Ducts exposed to weather shall be insulated and finished as specified for the applicable service for exposed duct inside the building. After the above is accomplished, the insulation shall then be further finished as detailed in the following subparagraphs.

3.3.7.2 Round Duct

Laminated self-adhesive (minimum 0.05 mm (2 mils) adhesive, 0.075 mm (3 mils) embossed) vapor barrier/weatherproofing jacket - Less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane shall be applied overlapping material by 75 mm (3 inches) no bands or caulking needed - see manufacturer's recommended installation instructions. Aluminum jacket with factory applied moisture retarder shall be applied with the joints lapped not less than 75 mm (3 inches) and secured with bands located at circumferential laps and at not more than 300 mm (12 inch) intervals throughout. Horizontal joints shall lap down to shed water and located at 4 or 8 o'clock position. Joints shall be sealed with caulking to prevent moisture penetration. Where jacketing abuts an un-insulated surface, joints shall be sealed with caulking.

3.3.7.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.7.4 Rectangular Ducts

Two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application shall be applied to the entire surface. Each coat of weatherproof mastic shall be 2 mm (1/16 inch) minimum thickness. The exterior shall be a metal jacketing applied for mechanical abuse and weather protection, and secured with screws.

3.3.8 Kitchen Exhaust Duct Insulation

NFPA 96 for ovens, griddles, deep fat fryers, steam kettles, vegetable steamers, high pressure cookers, and mobile serving units. Provide insulation with 19 mm (3/4 inch) wide, minimum 4 mm (0.15 inch) thick galvanized steel bands spaced not over 305 mm (12 inches) o.c.; or 16 gauge galvanized steel wire with corner clips under the wire; or with heavy welded pins spaced not over 305 mm (12 inches) apart each way. Do not use adhesives.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

3.4.1 General

Removable insulation sections shall be provided to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Equipment insulation shall be omitted on the following:

a. Hand-holes.

b. Boiler manholes.

c. Cleanouts.

d. ASME stamps.

e. Manufacturer's nameplates.

f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

Cold equipment below 16 degrees C (60 degrees F): Insulation shall be furnished on equipment handling media below 16 degrees C (60 degrees F) including the following:

a. Pumps.

b. Refrigeration equipment parts that are not factory insulated.

c. Drip pans under chilled equipment.

d. Cold water storage tanks.

e. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. Expansion and air separation tanks.

3.4.2.1 Insulation Type

Insulation shall be suitable for the temperature encountered. Material and thicknesses shall be as shown in Table 5:

TABLE 5		
Insulation Thickness for Cold Equipment (mm) (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (mm) (inches)
2 to 16 degrees C(35 to 60 degrees F)		
	Cellular Glass	40 (1.5)
	Faced Phenolic Foam	40 (1.5)
	Flexible Elastomeric Cellular	25 (1)
	Polyisocyanurate Foam	25 (1)
	Flexible Polyolefin Cellular	25 (1)
Minus 18 to 1 degree C(1 to 34 degrees F)		
	Faced Phenolic Foam	40 (1.5)
	Polyisocyanurate Foam	40 (1.5)
	Cellular Glass	75 (3)
	Flexible Elastomeric Cellular	40 (1.5)
	Flexible Polyolefin Cellular	40 (1.5)
Minus 34 to minus 17 degrees C(Minus 30 to 0 degrees F)		

TABLE 5		
Insulation Thickness for Cold Equipment (mm) (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (mm) (inches)
	Faced Phenolic Foam	40 (1.5)
	Polyisocyanurate Foam	45 (1.75)
	Cellular Glass	90 (3.5)
	Flexible Elastomeric Cellular	40 (1.5)
	Flexible Polyolefin Cellular	40 (1.5)

3.4.2.2 Pump Insulation

a. Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Joints between sides and between sides and bottom shall be joined by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible elastomeric cellular insulation. The box shall conform to the requirements of MICA Insulation Stds plate No. 49 when using flexible elastomeric cellular insulation. Joints between top cover and sides shall fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.

b. Exposed insulation corners shall be protected with corner angles.

c. Upon completion of installation of the insulation, including removable sections, two coats of vapor retarder coating shall be applied with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 2 mm (1/16 inch). A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Caulking shall be applied to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not more than 300 mm (12 inch) centers except flexible elastomeric cellular which shall be adhered with contact adhesive. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. Phenolic foam insulation shall be set in a coating of bedding compound and joints shall be sealed with bedding compound as recommended by the manufacturer. Cellular glass shall be installed in accordance with manufacturer's instructions. Joints and ends shall be sealed with joint sealant, and sealed with a vapor retarder coating.

d. Insulation on heads of heat exchangers shall be removable. Removable section joints shall be fabricated using a male-female shiplap type joint. The entire surface of the removable section shall be finished by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 2 mm (1/16 inch).

e. Exposed insulation corners shall be protected with corner angles.

f. Insulation on equipment with ribs shall be applied over 150 by 150 mm (6 by 6 inches) by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 50 by 50 mm (2 by 2 inches) washers or shall be securely banded or wired in place on 300 mm (12 inch) centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating or vapor barrier jacket shall be applied over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. The total dry thickness of the finish shall be 2 mm (1/16 inch). Caulking or vapor barrier tape shall be applied to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

Insulation shall be furnished on equipment handling media above 16 degrees C (60 degrees F) including the following:

a. Converters.

b. Heat exchangers.

c. Hot water generators.

d. Water heaters.

e. Pumps handling media above 54 degrees C (130 degrees F).

f. Fuel oil heaters.

g. Hot water storage tanks.

h. Air separation tanks.

i. Surge tanks.

j. Flash tanks.

k. Feed-water heaters.

l. Unjacketed boilers or parts of boilers.

m. Boiler flue gas connection from boiler to stack (if inside).

n. Induced draft fans.

o. Fly ash and soot collectors.

p. Condensate receivers.

3.4.3.1 Insulation

Insulation shall be suitable for the temperature encountered. Shell and tube-type heat exchangers shall be insulated for the temperature of the shell medium.

Insulation thickness for hot equipment shall be determined using Table 6:

TABLE 6		
Insulation Thickness for Hot Equipment (mm) (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (mm) (inches)
103 kPa or 121 degrees C(15 psig or 250 degrees F)		
	Rigid Mineral Fiber	50(2)
	Flexible Mineral Fiber	50(2)
	Calcium Silicate/Perlite	100(4)
	Cellular Glass	75(3)
	Faced Phenolic Foam	40(1.5)
	Flexible Elastomeric Cellular (<93 C(<200 F))	25(1)
	Polyisocyanurate Foam	25(1)
1380 kPa or 204 degree C(200psig or 400 degrees F)		
	Rigid Mineral Fiber	75(3)
	Flexible Mineral Fiber	75(3)
	Calcium Silicate/Perlite	100(4)
	Cellular Glass	100(4)
316 degrees C(600 degrees F)		
	Rigid Mineral Fiber	125(5)
	Flexible Mineral Fiber	150(6)
	Calcium Silicate/Perlite	150(6)
	Cellular Glass	150(6)

TABLE 6		
Insulation Thickness for Hot Equipment (mm) (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (mm) (inches)
316 degrees C(600 degrees F): Thickness necessary to limit the external temperature of the insulation to 50 C (120 F). Heat transfer calculations shall be submitted to substantiate insulation and thickness selection.		

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside boiler House or mechanical Room, bevel insulation neatly around openings and provide sheet metal insulation stop strips around such openings. Apply a skim coat of hydraulic setting cement directly to insulation. Apply a flooding coat of adhesive over hydraulic setting cement, and while still wet, press a layer of glass cloth or tape into adhesive and seal laps and edges with adhesive. Coat glass cloth with adhesive. When dry, apply a finish coat of adhesive at can-consistency so that when dry no glass weave shall be observed. Provide metal jackets for stacks and exhaust pipes that are located above finished floor and spaces outside boiler house or mechanical room. Apply metal jackets directly over insulation and secure with 19 mm (3/4 inch) wide metal bands spaced on 457 mm (18 inch) centers. Do not insulate name plates. Insulation type and thickness shall be in accordance with the following Table 7.

TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees C(F))						
	Material	Outside Diameter (mm) (Inches)				
		6 - 32 (0.25-1.25)	25 - 80 (1-1.67)	90-125 (3.5-5)	150 - 250 (6-10)	> or = 280-900 (11-36)
Boiler Stack (Up to 204 degrees C) (Up to 400 degrees F)						
	Mineral Fiber ASTM C553 Class B-3, ASTM C547 Class 1, or ASTM C612 Class 1	N/A	N/A	75 (3)	90 (3.5)	100 (4)

TABLE 7

Insulation and Thickness for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees C(F))					
Material	Outside Diameter (mm) (Inches)				
	6 - 32 (0.25-1.25)	25 - 80 (1-1.67)	90-125 (3.5-5)	150 - 250 (6-10)	> or = 280-900 (11-36)
Calcium Silicate ASTM C533, Type 1	N/A	N/A	75 (3)	90 (3.5)	100 (4)
Cellular Glass ASTM C552, Type II	40 (1.5)	40 (1.5)	40 (1.5)	50 (2)	65 (2.5)
Boiler Stack (205 to 315 degrees C) (401 to 600 degrees F)					
Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	100 (4)	100 (4)	125 (5)
Calcium Silicate ASTM C533, Type I or II	N/A	N/A	100 (4)	100 (4)	100 (4)
Mineral Fiber/Cellular Glass Composite:					
Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	25 (1)	25 (1)	25 (1)	25 (1)	50 (2)
Cellular Glass ASTM C552, Type II	50 (2)	50 (2)	50 (2)	50 (2)	50 (2)
Boiler Stack (316 to 427 degrees C) (601 to 800 degrees F)					
Mineral Fiber ASTM C547 Class 3, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	100 (4)	100 (4)	150 (6)

TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees C(F))						
	Material	Outside Diameter (mm) (Inches)				
		6 - 32 (0.25-1.25)	25 - 80 (1-1.67)	90-125 (3.5-5)	150 - 250 (6-10)	> or = 280-900 (11-36)
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	100 (4)	100 (4)	150 (6)
	Mineral Fiber/Cellular Glass Composite:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	50 (2)	50 (2)	50 (2)	80 (3)	80 (3)
	Cellular Glass ASTM C552, Type II	50 (2)	50 (2)	50 (2)	50 (2)	50 (2)
Diesel Engine Exhaust (Up to 371 degrees C) (Up to 700 degrees F)						
	Calcium Silicate ASTM C533, Type I or II	80 (3)	90 (3.5)	100 (4)	100 (4)	100 (4)
	Cellular Glass ASTM C552, Type II	65 (2.5)*	90 (3.5)	100 (4)	115 (4.5)	150 (6)

3.4.3.3 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing that does not rest on the pump. Joints between top cover and sides shall fit tightly. The top cover shall have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Two coats of Class I adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish shall be 2 mm (1/16 inch). Caulking shall be applied to parting line of the removable sections and penetrations.

3.4.3.4 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not greater than 300 mm (12 inch) centers except flexible elastomeric cellular which shall be adhered. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. On high vibration equipment, cellular glass insulation shall be set in a coating of bedding compound as recommended by the manufacturer, and joints shall be sealed with bedding compound. Mineral fiber joints shall be filled with finishing cement.

d. Insulation on heads of heat exchangers shall be removable. The removable section joint shall be fabricated using a male-female shiplap type joint. Entire surface of the removable section shall be finished as specified.

e. Exposed insulation corners shall be protected with corner angles.

f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, insulation shall be applied over 150 by 150 mm (6 by 6 inch) by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 50 by 50 mm (2 by 2 inch) washers or shall be securely banded or wired in place on 300 mm (12 inch) (maximum) centers.

g. On equipment handling media above 316 degrees C (600 degrees F), insulation shall be applied in two or more layers with joints staggered.

h. Upon completion of installation of insulation, penetrations shall be caulked. Two coats of adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 2 mm (1/16 inch). Caulking shall be applied to parting line between equipment and removable section insulation.

3.4.4 Equipment Handling Dual Temperature Media

Below and above 16 degrees C (60 degrees F): equipment handling dual temperature media shall be insulated as specified for cold equipment.

3.4.5 Equipment Exposed to Weather

3.4.5.1 Installation

Equipment exposed to weather shall be insulated and finished in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.5.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance shall be equal to or better than that specified for field applied insulation. Panels shall be the standard catalog product of a manufacturer of metal insulation panels. Fastenings, flashing, and support system shall conform to published recommendations of the manufacturer for weatherproof installation and shall prevent moisture from entering the insulation. Panels shall be designed to accommodate thermal expansion and to support a 1112 N (250 pound) walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet shall be aluminum and exposed fastenings shall be stainless steel or aluminum.

-- End of Section --

SECTION 23 08 00.00 10

COMMISSIONING OF HVAC SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

ACG Commissioning Guideline (2005) Commissioning Guideline

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Commissioning Standard (2009) Procedural Standards for Whole Building Systems Commissioning of New Construction; 3rd Edition

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1429 (1994) HVAC Systems Commissioning Manual, 1st Edition

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC Leadership in Energy and Environmental Design(tm) New Construction Rating System

1.2 DEFINITIONS

In some instances, terminology differs between the Contract and the Commissioning Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding ACG, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	ACG	NEBB	TABB
Commissioning Standard	ACG Commissioning Guideline	Procedural Standards for Building Systems Commissioning	SMACNA HVAC Commissioning Guidelines

SIMILAR TERMS			
Contract Term	ACG	NEBB	TABB
Commissioning Specialist	ACG Certified Commissioning Agent	NEBB Qualified Commissioning Administrator	TABB Certified Commissioning Supervisor

1.3 SYSTEM DESCRIPTION

1.3.1 General

Perform Commissioning in accordance with the requirements of the standard under which the Commissioning Firm's qualifications are approved, i.e., ACG Commissioning Guideline, NEBB Commissioning Standard, or SMACNA 1429 unless otherwise stated herein. Consider mandatory all recommendations and suggested practices contained in the Commissioning Standard. Use the Commissioning Standard for all aspects of Commissioning, including qualifications for the Commissioning Firm and Specialist and calibration of Commissioning instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the Commissioning Standard, the manufacturer's recommendations shall be adhered to. All quality assurance provisions of the Commissioning Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the Commissioning Standard, Commissioning procedures shall be developed by the Commissioning Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the Commissioning Standard used (ACG, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

1.3.2 Energy

Formal LEED NC certification is not required; however, the Contractor is required to provide documentation that meets the LEED NC Energy & Atmosphere (EA) Prerequisite 1, Fundamental Commissioning. For New Construction and Major Revisions provide, also, documentation that meets EA Credit 3; Enhanced Commissioning. Provide documentation for as many LEED credits as possible to support LEED Silver certification of the project.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Commissioning Plan; G,

SD-03 Product Data

Pre-Functional Performance Test Checklists; G, Functional Performance Tests; G,

SD-06 Test Reports

Commissioning Report; G

SD-07 Certificates

Commissioning Firm; G
Commissioning Specialist; G

1.5 QUALITY ASSURANCE

1.5.1 Commissioning Firm

Submit certification of the proposed Commissioning Firm's qualifications to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. Include in the documentation the date that the Certification was initially granted and the date when the current Certification expires. The firm is either a member of ACG or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications. Any lapses in Certification of the proposed Commissioning Firm or disciplinary action taken by ACG, NEBB, or TABB against the proposed Commissioning Firm shall be described in detail. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, immediately notify the Contracting Officer and submit another Commissioning Firm for approval. Any firm that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including Commissioning. All work specified in this Section and in other related Sections to be performed by the Commissioning Firm shall be considered invalid if the Commissioning Firm loses its certification prior to Contract completion and must be performed by an approved successor. These Commissioning services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The Commissioning Firm shall be a subcontractor of the prime Contractor and shall be financially and corporately independent of all other subcontractors. The Commissioning Firm shall report to and be paid by the prime Contractor.

1.5.2 Commissioning Specialist

1.5.2.1 General

Submit certification of the proposed Commissioning Specialist's qualifications to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date when the current Certification expires. The Commissioning Specialist shall be an ACG Certified Commissioning Agent, a NEBB Qualified Commissioning Administrator, or a TABB Certified Commissioning Supervisor and shall be an employee of the approved Commissioning Firm. Any lapses in Certification of the proposed Commissioning Specialist or disciplinary action taken by ACG, NEBB, or TABB against the proposed Commissioning Specialist shall be described in detail. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Commissioning Specialist loses subject certification during this period, immediately notify the Contracting Officer and submit another Commissioning Specialist for approval. Any individual that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including Commissioning. All work specified in this Section and in other related Sections performed by the Commissioning Specialist shall be considered invalid if the Commissioning Specialist loses certification prior to Contract completion and must be performed by the approved successor.

1.5.2.2 Responsibilities

Perform all Commissioning work specified herein and in related sections under the direct guidance of the Commissioning Specialist. The Commissioning Specialist shall prepare, no later than 28 days after the approval of the Commissioning Specialist, the Commissioning Plan which will be a comprehensive schedule and will include all submittal requirements for procedures, notifications, reports and the Commissioning Report. After approval of the Commissioning Plan, revise the Contract NAS schedule to reflect the schedule requirements in the Commissioning Plan.

1.6 SEQUENCING AND SCHEDULING

Begin the work described in this Section only after all work required in related Sections has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Pre-Functional Performance Test Checklists shall be performed at appropriate times during the construction phase of the Contract.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 COMMISSIONING TEAM AND TEST FORMS AND CHECKLISTS

Designate Contractor team members to participate in the Pre- Functional Performance Test Checklists and the Functional Performance Tests specified herein. In addition, the Government team members will include a representative of the Contracting Officer, the Design Agent's Representative, and the Using Agency's Representative. The team members shall be as follows:

Designation	Function
A	Contractor's Commissioning Specialist
M	Contractor's Mechanical Representative
E	Contractor's Electrical Representative
T	Contractor's Testing, Adjusting, and Balancing (TAB) Specialist

Designation	Function
C	Contractor's Controls Representative
D	Design Agency Representative
O	Contracting Officer's Representative
U	Using Agency's Representative

Appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each Pre- Functional Performance Test Checklist item shall be indicated by initials and date unless an "X" is shown indicating that participation by that individual is not required. Acceptance by each commissioning team member of each functional performance test item shall be indicated by signature and date.

3.2 TESTS

Perform the pre-functional performance test checklists and functional performance tests in a manner that essentially duplicates the checking, testing, and inspection methods established in the related Sections. Where checking, testing, and inspection methods are not specified in other Sections, establish methods which will provide the information required. Testing and verification required by this section shall be performed during the Commissioning phase. Requirements in related Sections are independent from the requirements of this Section and shall not be used to satisfy any of the requirements specified in this Section. Provide all materials, services, and labor required to perform the pre- functional performance tests checks and functional performance tests. A functional performance test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating non-Government commissioning team member of which participation is specified is not present for the test.

3.2.1 Pre-Functional Performance Test Checklists

Perform Pre-Functional Performance Test Checklists, for the items indicated in Appendix A, at least 28 days prior to the start of Pre-Functional Performance Test Checks. Correct and re-inspect deficiencies discovered during these checks in accordance with the applicable contract requirements. Submit the schedule for the test checks at least 14 days prior to the start of Pre-Functional Performance Test Checks.

3.2.2 Functional Performance Tests

Submit test procedures at least 28 days prior to the start of Functional Performance Tests. Submit the schedule for the tests at least 14 days prior to the start of Functional Performance Tests. Perform Functional Performance Tests for the items indicated in Appendix B. Begin Functional Performance Tests only after all Pre-Functional Performance Test Checklists have been successfully completed. Tests shall prove all modes of the sequences of operation, and shall verify all other relevant contract requirements. Begin Tests with equipment or components and progress through subsystems to complete systems. Upon failure of any Functional Performance Test item, correct all deficiencies in accordance with the applicable contract requirements. The item shall then be retested until it has been completed with no errors.

3.3 COMMISSIONING REPORT

Submit the Commissioning Report, no later than 14 days after completion of Functional Performance Tests, consisting of completed Pre- Functional Performance Test Checklists and completed Functional Performance Tests organized by system and by subsystem and submitted as one package. The Commissioning Report shall also include all HVAC systems test reports, inspection reports (Preparatory, Initial and Follow-up inspections), start-up reports, TAB report, TAB verification report, Controls start-up test reports and Controls Performance Verification Test (PVT) report. The results of failed tests shall be included along with a description of the corrective action taken.

APPENDIX A

PRE-FUNCTIONAL PERFORMANCE TEST CHECKLISTS

Pre-Functional Performance Test Checklist - Multizone Air Handling Unit

For Air Handling Unit:

Checklist Item	A	M	E	T	C	O
Installation						
a. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed. (Visually verify pan drains completely by pouring a cup of water into drain pan.)	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	X	___	X	X	___
b. Power available to unit control panel.	___	X	___	X	X	___
c. Proper motor rotation verified.	___	X	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	X	___
e. Power available to electric heating coil.	___	X	___	X	X	___

Coils	A	M	E	T	C	O
a. Chilled water piping properly connected.	___	___	X	X	X	___
b. Refrigerant piping properly connected.	___	___	X	X	X	___
c. Hot water piping properly connected.	___	___	X	X	X	___
d. Steam and condensate piping properly connected.	___	___	X	X	X	___

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	X	X	X	___	___
b. Control valves/actuators operable.	___	X	X	X	___	___
c. O/A dampers/actuators properly installed.	___	X	X	X	___	___
d. O/A dampers/actuators operable.	___	X	X	X	___	___

Pre-Functional Performance Test Checklist - Multizone Air Handling Unit (cont)

	A	M	E	T	C	O

e. Zone dampers/actuators properly installed & dampers leak checked.	___	X	X	X	___	___
f. Zone dampers/actuators operable.	___	X	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. Construction filters removed and replaced.	___	___	X	___	X	___
b. TAB report approved.		___	X	X	___	X

Pre-Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit:

Checklist Item	A	M	E	T	C	O
Installation						
a. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed. (Visually verify drainage by pouring a cup of water into drain pan.)	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	X	___	X	X	___
b. Power available to unit control panel.	___	X	___	X	X	___
c. Proper motor rotation verified.	___	X	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	X	___
e. Power available to electric heating coil.	___	X	___	X	X	___

Coils	A	M	E	T	C	O
a. Chilled water piping properly connected.	___	___	X	X	X	___
b. Refrigerant piping properly connected.	___	___	X	X	X	___
c. Hot water piping properly connected.	___	___	X	X	X	___
d. Steam and condensate piping properly connected.	___	___	X	X	X	___

Pre-Functional Performance Test Checklist - Variable Volume Air Handling Unit

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	X	X	X	___	___
b. Control valves/actuators operable.	___	X	X	X	___	___
c. Dampers/actuators properly installed.	___	X	X	X	___	___
d. Dampers/actuators operable.	___	X	X	X	___	___
e. Verify proper location, installation and calibration of duct static pressure sensor.	___	X	X	X	___	___
f. Fan air volume controller operable.	___	X	X	X	___	___
g. Air handler controls system operational.	___	X	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. Construction filters removed and replaced.	___	___	X	___	___	___
b. TAB report approved.	___	X	X	___	X	___

Pre-Functional Performance Test Checklist - VAV Terminal

For VAV Terminal:

Checklist Item	A	M	E	T	C	O
Installation						
a. Reheat coil connected to hot water pipe.	___	___	X	___	X	___
b. Electric reheat coil connected to local disconnect.	___	X	___	___	X	___

Controls	A	M	E	T	C	O
a. Cooling only VAV terminal controls set.	___	X	X	X	___	___
b. Cooling only VAV controls verified.	___	X	X	X	___	___
c. Reheat VAV terminal controls set.	___	X	X	X	___	___
d. Reheat terminal/coil controls verified.	___	X	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - DX Air Cooled Condensing Unit

For Condensing Unit:

Checklist Item	A	M	E	T	C	O
Installation						
a. Check condenser fans for proper rotation.	___	___	X	___	X	___
Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	X	___	X	X	___
b. Power available to unit control panel.	___	X	___	X	___	___
c. Verify that power disconnect is located within sight of the unit it controls	___	X	___	X	___	___
Controls	A	M	E	T	C	O
a. Unit safety/protection devices tested.	___	___	X	X	___	___
b. Control system and interlocks installed.	___	___	X	X	___	___
c. Control system and interlocks operational.	___	___	X	X	___	___

Pre-Functional Performance Test Checklist - Pumps

For Pump:

Checklist Item	A	M	E	T	C	O
Installation						
a. Piping system installed.	___	___	X	X	X	___

Electrical	A	M	E	T	C	O
a. Power available to pump disconnect.	___	X	___	X	X	___
b. Pump rotation verified.	___	X	___	X	X	___
c. Control system interlocks functional.	___	X	___	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. Pressure/temperature gauges installed.	___	___	X	___	X	___
b. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller:

Checklist Item	A	M	E	T	C	O
Installation						
a. Chiller properly piped.	___	___	X	___	___	___
Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	X	___	X	___	___
b. Power available to unit control panel.	___	X	___	X	___	___
c. Separate power is supplied to electric heating tape.	___	X	___	X	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	___	___
Controls	A	M	E	T	C	O
a. Factory startup and checkout complete.	___	___	X	X	___	___
b. Chiller safety/protection devices tested.	___	___	X	X	___	___
c. Chilled water flow switch installed.	___	___	X	X	___	___
d. Chilled water flow switch tested.	___	___	X	X	___	___
e. Chilled water pump interlock installed.	___	___	X	X	X	___
f. Chilled water pump interlock tested.	___	___	___	X		

Pre-Functional Performance Test Checklist - Centrifugal Chiller

For Chiller:

Checklist Item

Installation	A	M	E	T	C	O
a. Chilled water connections properly piped.	___	___	X	___	___	___
b. Condenser water connections properly piped	___	___	X	___	___	___
c. Refrigerant leak detector installed.	___	___	___	___	___	___
d. Oxygen sensor installed and tested.	___	___	___	___	___	___
e. Mechanical room ventilation installed as specified.	___	___	___	___	___	___

Electrical	A	M	E	T	C	O
a. Power available to unit starter.	___	X	___	X	___	___
b. Power available to unit control panel.	___	X	___	X	___	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	___	___

Controls	A	M	E	T	C	O
a. Factory startup and checkout complete.	___	___	X	X	___	___
b. Chiller safety/protection devices tested.	___	___	___	X	___	___
c. Chilled water flow switch installed and tested.	___	___	X	X	___	___
d. Chilled water pump interlock installed and tested.	___	___	___	X	___	___
e. Condenser water flow switch installed and tested.	___	___	___	X	___	___
f. Condenser water pump interlock installed and tested.	___	___	___	X	___	___

Pre-Functional Performance Test Checklist - Cooling Tower

For Cooling Tower:

Checklist Item

Installation	A	M	E	T	C	O
a. Cooling tower properly piped.	___	___	X	X	___	___
b. Cooling tower fan drive adjusted.	___	___	___	___	X	___
c. Cooling tower makeup water supply piped.	___	___	X	X	___	___
d. Verify makeup control valve shutoff.	___	___	X	___	X	___
e. Fan lubricated and blade pitch adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to tower disconnect.	___	X	___	X	___	___
b. Power available to electric sump heater.	___	X	___	X	___	___
c. Control system interlocks functional.	___	___	___	X	___	___
d. Motor and fan rotation checked.	___	X	___	X	___	___
e. Verify that power disconnect is located within sight of the unit is controls.	___	X	___	X	___	___

Piping	A	M	E	T	C	O
a. Condenser water treatment functional.	___	___	X	X	X	___
b. All required temperature sensing wells, pressure ports and flow sensors have been installed for performance tests.	___	___	___	___	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB report approved.	___	___	X	___	X	_____

Pre-Functional Performance Test Checklist - Hot Water Boiler

For Boiler:

Checklist Item

Installation	A	M	E	T	C	O
a. Boiler hot water piping installed.	___	___	X	___	___	___
b. Boiler makeup water piping installed.	___	___	X	___	___	___
c. Boiler fuel oil piping installed.	___	___	X	X	X	___
d. Boiler gas piping installed.	___	___	X	X	X	___

Startup	A	M	E	T	C	O
a. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre- and post-purge, have been tested.	___	___	___	X	___	___
b. Verify that PRV rating conforms to boiler rating.	___	___	___	X	___	___
c. Boiler water treatment system functional.	___	___	X	X	___	___
d. Boiler startup and checkout complete.	___	___	X	X	___	___
e. Combustion efficiency demonstrated.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Verify that power disconnect is located within sight of the unit served.	___	X	___	X	___	___

Controls	A	M	E	T	C	O
a. Hot water pump interlock installed and tested.	___	___	___	X	___	___
b. Hot water proof-of-flow switch installed and tested	___	___	X	X	___	___
c. Hot water heating controls operational.	___	___	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Steam Boiler

For Boiler:

Checklist Item

Installation	A	M	E	T	C	O
a. Boiler steam piping installed.	___	___	X	X	X	___
b. Boiler makeup water piping installed.	___	___	X	___	X	___
c. Boiler fuel oil piping installed.	___	___	X	X	X	___
d. Boiler gas piping installed.	___	___	X	X	X	___

Startup	A	M	E	T	C	O
a. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre and post purge, have been tested.	___	___	___	X	___	___
b. Verify that PRV rating conforms to boiler rating.	___	___	___	X	___	___
c. Boiler feed water system operational.	___	___	___	X	___	___
d. Boiler water treatment system functional.	___	___	X	X	X	___
e. Boiler startup and checkout complete.	___	___	___	X	___	___
f. All steam traps operational.	___	___	X	X	X	___
g. All condensate return pumps operational.	___	___	___	___	X	___
h. Combustion efficiency demonstrated.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Verify that power disconnect is located within sight of the unit served.	___	X	___	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Steam/Hot Water Converter

For Converter:

Checklist Item

Installation	A	M	E	T	C	O
a. Converter steam piping installed.	___	___	X	___	X	___
b. Hot water piping installed.	___	___	X	___	___	___
c. Makeup water piping installed.	___	___	X	X	X	___
d. Vacuum breaker installed on shell of shell and tube unit.	___	___	X	X	X	___

Startup	A	M	E	T	C	O
a. All steam traps operational.	___	___	X	X	X	___
b. All condensate return pumps operational.	___	___	___	X	___	___
c. Converter safety/protection devices tested.	___	___	X	X	X	___
d. Converter startup and checkout complete.	___	___	X	X	X	___

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___

Pre-Functional Performance Test Checklist - Fan Coil Unit

For Fan Coil Unit:

Checklist Item

Installation	A	M	E	T	C	O
a. Access doors/removable panels are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed.	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	___	___	X	___	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
e. Power available to electric heating coil.	___	___	___	X	X	___

Coils	A	M	E	T	C	O
a. Dual temperature piping properly connected.	___	___	X	___	___	___
b. Chilled water piping properly connected.	___	___	X	X	X	___
c. Hot water piping properly connected.	___	___	X	___	___	___

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	X	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Unit Heater

For Unit Heater:

Checklist Item

Installation	A	M	E	T	C	O
a. Hot water piping properly connected.	___	___	X	___	___	___
b. Steam and condensate piping properly connected.	___	___	X	X	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	___	___	X	___	___
b. Proper motor rotation verified.	___	___	___	X	X	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
d. Power available to electric heating coil.	___	___	___	X	___	___

Controls	A	M	E	T	C	O
a. Control valves properly installed.	___	___	X	___	___	___
b. Control valves operable.	___	___	X	X	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Exhaust Fan

For Exhaust Fan:

Checklist Item

Installation	A	M	E	T	C	O
a. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to fan disconnect.	___	___	___	X	___	___
b. Proper motor rotation verified.	___	___	___	___	X	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___

Controls	A	M	E	T	C	O
a. Control interlocks properly installed.	___	___	___	X	___	___
b. Control interlocks operable.	___	___	___	X	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Computer Room Unit

For Computer Room Unit:

Checklist Item

Installation	A	M	E	T	C	O
a. Access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed and routed to floor drain.	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	X	___	X	X	___
b. Proper motor rotation verified.	___	X	___	___	X	___
c. Proper motor rotation verified.	___	X	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	___	___
e. Power available to reheat coils.	___	X	___	___	X	___

Coils/Humidifier	A	M	E	T	C	O
a. Chilled water piping properly connected.	___	___	X	___	___	___
b. Refrigerant piping properly connected.	___	___	X	X	X	___
c. Hot water piping properly connected.	___	___	X	___	___	___
d. Steam piping properly connected.	___	___	X	X	X	___
e. Humidifier makeup water connected.	___	___	X	X	X	___

Controls	A	M	E	T	C	O
a. Control valves operable.	___	___	X	X	___	___
b. Unit control system operable and verified.	___	___	___	X	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report submitted.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - HVAC System Controls

For HVAC System:

Checklist Item

Installation	A	M	E	T	C	O
a. Layout of control panel matches drawings.	___	___	X	X	___	___
b. Framed instructions mounted in or near control panel.	___	___	X	X	___	___
c. Components properly labeled (on inside and outside of panel).	___	___	X	X	___	___
d. Control components piped and/or wired to each labeled terminal strip.	___	___	X	X	___	___
e. EMCS connection made to each labeled terminal strip as shown.	___	___	X	X	___	___
f. Control wiring and tubing labeled at all terminations, splices, and junctions.	___	___	X	X	___	___

Main Power and Control Air	A	M	E	T	C	O
a. 120 volt AC power available to panel.	___	___	___	X	___	___
b. 138 kPa gauge(20 psig) compressed air available to panel.	___	___	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report submitted.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Single Zone Air Handling Unit

For Air Handling Unit:

Checklist Item

Installation	A	M	E	T	C	O
a. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed.	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	___	___	X	X	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
e. Power available to electric heating coil.	___	___	___	X	___	___

Coils	A	M	E	T	C	O
a. Chilled water piping properly connected.	___	___	X	___	___	___
b. Refrigerant piping properly connected.	___	___	X	X	X	___
c. Hot water piping properly connected.	___	___	X	___	___	___
d. Steam and condensate piping properly connected.	___	___	X	X	X	___

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O

a. TAB Report approved. ___ ___ X ___ X ___

Pre-Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System:

Checklist Item

Installation	A	M	E	T	C	O
a. Recovery system piping installed.	___	___	X	___	X	___

Startup	A	M	E	T	C	O
a. Startup and checkout complete.	___	___	X	X	X	___

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___

- End of Appendix A -

APPENDIX B

FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

Functional Performance Test - Pump

NOTE: Prior to performing this test, for closed loop systems ensure that the system is pressurized and the make-up water system is operational, or for open loop systems ensure that the sumps are filled to the proper level.

1. Activate pump start using control system commands.

a. Verify correct operation in:

HAND__________ OFF__________ AUTO__________

b. Verify pressure drop across strainer:

Strainer inlet pressure __________ kPa gauge(psig)

Strainer outlet pressure _________ kPa gauge(psig)

c. Verify pump inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report and pump design conditions.

	DESIGN	TAB	ACTUAL
Pump inlet pressure kPa gauge(psig)	_________	__________	__________
Pump outlet pressure kPa gauge(psig)	_________	__________	__________

d. Operate pump at shutoff and at 100 percent of designed flow when all components are in full flow. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure kPa gauge(psig)	__________	__________
Pump outlet pressure kPa gauge(psig)	__________	__________
Pump flow rate L/s(gpm)	__________	__________

	SETPOINT
Differential Pressure Transmitter	________

Functional Performance Test (cont) - Pump

e. For variable speed pumps, operate pump at shutoff (shutoff to be done in manual on variable speed drive at the minimum rpm that the system is being controlled at) and at minimum flow or when all components are in full by-pass. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure kPa gauge(psig)	___________	___________
Pump outlet pressure kPa gauge(psig)	___________	___________
Pump flow rate L/s(gpm)	___________	___________

	SETPOINT
Differential Pressure Transmitter	_________

2. Measure motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions. Compare amperage to nameplate FLA.

a. Full flow:

Nameplate FLA ___________

Amperage	Phase 1 ___________	Phase 2___________	Phase 3___________
Voltage	Ph1-Ph2 ___________	Ph1-Ph3___________	Ph2-Ph3___________
Voltage	Ph1-gnd ___________	Ph2-gnd___________	Ph3-gnd___________

b. Minimum flow:

Amperage	Phase 1 ___________	Phase 2___________	Phase 3___________
Voltage	Ph1-Ph2 ___________	Ph1-Ph3___________	Ph2-Ph3___________
Voltage	Ph1-gnd ___________	Ph2-gnd___________	Ph3-gnd___________

3. Note unusual vibration, noise, etc.

____

____

Functional Performance Test (cont) - Pump

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	______________________________
Contractor's Mechanical Representative	______________________________
Contractor's Electrical Representative	______________________________
Contractor's TAB Representative	______________________________
Contractor's Controls Representative	______________________________
Contracting Officer's Representative	______________________________
Design Agency Representative	______________________________
Using Agency's Representative	______________________________

Functional Performance Test - Centrifugal Chiller

Note: If water-cooled chiller perform in conjunction with Cooling Tower test.

1. Demonstrate operation of chilled water system in accordance with specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows:

a. Time of day startup program initiates chiller start: ____________

b. Record outdoor air temperature: ____________

c. Start condenser water pump and establish condenser water flow. Verify chiller condenser water proof-of-flow switch operation._____

d. Start chilled water pump and establish chilled water flow. Verify chiller chilled water proof-of-flow switch operation. ____________

e. Verify control system energizes chiller start sequence.__________

f. Verify chiller senses chilled water temperature above set point and control system activates chiller start. _________________________

g. Verify functioning of "soft start" sequence. __________________

h. Record data in 2, 3 and 4 below on fully load chiller.

i. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed.
____

j. Restart air-handling equipment one minute after chiller shut down. Verify condenser water pump, cooling tower, and chiller restart sequence.
____

2. Verify chiller inlet/outlet pressure and flow reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

	DESIGN	TAB REPORT	ACTUAL
Chiller inlet pressure kPa gauge(psig)	_________	_________	________
Chiller outlet pressure kPa gauge(psig)	_________	_________	________
Chiller flow L/sec(GPM)	_________	_________	________

3. Measure chiller amperage each phase and voltage phase to phase and phase to ground for both the fully loaded condition.

				Motor F/L AMPS
Amperage	Phase 1 __________	Phase 2__________	Phase 3_______	_________
Voltage	Ph1-Ph2 __________	Ph1-Ph3__________	Ph2-Ph3_______	

Voltage Ph1-gnd ___________ Ph2-gnd___________ Ph3-gnd________

Functional Performance Test (cont) - Centrifugal Chiller

4. a. Record the following information: Design

Outdoor air temperature ________________ deg C(F)
Ambient dry bulb temperature ____________ deg C(F) _________
Entering chilled water temperature _____ deg C(F) _________
Leaving chilled water temperature ______ deg C(F) _________

b. Calculate chiller load at ambient conditions and compare to chiller rated capacity from manufacturer's literature. Calculated ________ KWs(Ton) Rated ________ KWs(Ton).

5. Unusual vibration, noise, etc.
____

____

6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________
Contracting Officer's Representative	_____________________________
Design Agency Representative	_____________________________
Using Agency's Representative	_____________________________

Functional Performance Test - Cooling Tower

1. Demonstrate operation of the cooling tower in accordance with specification and the following:

a. Activate cooling tower fan start using control system command. This should first start condenser water pump, establish flow, delay fan start, as specified, to equalize flow in distribution basin and sump. Verify fan start after timed delay.____________________________________

b. After chiller startup, control system should modulate bypass valve and two-speed fan motor to maintain condenser water set point. Verify function of bypass valve under varying loads. __________________

c. Verify cooling tower interlock with chiller._____________________

d. Verify makeup water float valve is functioning. ___________________

e. Activate chemical treatment feed valve, verify makeup of chemical treatment system, pump, and controls.______________________________

f. Record the following:

Entering water temperature _____ deg C(F)
Leaving water temperature: _____ deg C(F)
Measured water flow: _____ L/s(gpm)
Entering air wet bulb temperature: _____ deg C(F)

2. Compare results with test results from cooling tower specification test.

3. a. Stop all building cooling equipment so that cooling tower pumps stop. Observe tower for at least 15 minutes and verify no overflow occurs___________.

b. Start cooling tower pumps in hand and observe pumps for air binding/cavitation , none allowed __________.

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________
Contracting Officer's Representative	_____________________________
Design Agency Representative	_____________________________
Using Agency's Representative	_____________________________

Functional Performance Test Checklist - VAV Terminals

The Contracting officer will select VAV terminals to be spot-checked during the functional performance test. The number of terminals selected shall not exceed 10 percent.

1. Functional Performance Test: Contractor shall demonstrate operation of selected VAV boxes in accordance with specifications including the following:

a. Cooling only VAV boxes:

(1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to 3 degrees C(5 degrees F) below ambient and measure maximum airflow. Turn thermostat to 3 degrees C(5 degrees F) above ambient and measure minimum airflow.

	Setting	Measured	Design
Maximum flow	______	______	______ L/s(cfm)
Minimum flow	______	______	______ L/s(cfm)

b. Cooling with reheat VAV boxes:

(1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to 3 degrees C(5 degrees F) above ambient and measure maximum airflow. Turn thermostat to 3 degrees C(5 degrees F) below ambient and measure minimum airflow.

	Setting	Measured	Design
Maximum flow	______	______	______ L/s(cfm)
Minimum flow	______	______	______ L/s(cfm)

(2) Verify reheat coil operation range (full closed to full open) by turning room thermostat 3 degrees C(5 degrees F) above ambient _______.

With heating water system and boiler in operation providing design supply hot water temperature record the following:

Design HW supply temperature______ deg C(F)
Actual HW supply temperature______ deg C(F)
AHU supply air temperature______ deg C(F)
VAV supply air temperature______ deg C(F)
Calculate coil capacity and compare to design:
Design ______ W(BTU/hr) Actual _____W(BTU/hr)

Functional Performance Test Checklist (cont)- VAV Terminals

c. Parallel Fan powered VAV boxes:

(1) Verify VAV box responses to call for heating via set point adjustment. Change from cooling set point to heating set point. Verify cooling damper closes to minimum position, blower fan energizes according to sequence of operation, and upon further drop in space temperature, heating coil activation. __________

With heating water system in operation providing design supply hot water temperature record the following:

Design HW supply temperature______ deg C(F)
Actual HW supply temperature______ deg C(F)
AHU supply air temperature______ deg C(F)
VAV supply air temperature______ deg C(F)
Calculate coil capacity and compare to design:
Design ______ W(BTU/hr) Actual _____W(BTU/hr)

(2) Check primary air damper maximum/minimum flow settings and compare to actual measured flows.

	Setting	Measured	Design	
Maximum flow	______	______	______	L/s(cfm)
Minimum flow	______	______	______	L/s(cfm)

(3) Check blower fan flow. _____ L/s(cfm)

(4) Verify free operation of fan backdraft damper (insure no primary air is being discharged into plenum space).

---

d. Series Fan Powered VAV boxes

(1) Ensure VAV fan starts prior to AHU fan

(2) Verify VAV box response to sensor call for heating via set point adjustment. Change from cooling set point to heating set point. Verify cooling damper closes to minimum position and upon further drop in space temperature, heating coil activation. With heating water system and boiler in operation providing design supply hot water temperature record the following:

Design HW supply temperature______ deg C(F)
Actual HW supply temperature______ deg C(F)
AHU supply air temperature______ deg C(F)
VAV supply air temperature______ deg C(F)
Calculate coil capacity and compare to design:
Design ______ W(BTU/hr) Actual _____W(BTU/hr)

(3) Check primary air damper maximum/minimum flow settings and compare to actual measured flows.

	Setting	Measured	Design	
Maximum flow	______	______	______	L/s(cfm)

Minimum flow ______ ______ ______ L/s(cfm)

Functional Performance Test Checklist (cont)- VAV Terminals

(4) Verify that minimal primary air is discharging into the plenum space when in full cooling mode.

(5) Verify that no plenum air is being induced from the plenum space into the supply air during full cooling by measuring supply air temperature and comparing to primary air temperature

Primary air temp _____ deg C(F)
Supply air temp _____ deg C(F)

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	___________________________
Contractor's Mechanical Representative	___________________________
Contractor's Electrical Representative	___________________________
Contractor's TAB Representative	___________________________
Contractor's Controls Representative	___________________________
Contracting Officer's Representative	___________________________
Design Agency Representative	___________________________
Using Agency's Representative	___________________________

Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit:

1. Functional Performance Test: Contractor shall verify operation of air handling unit in accordance with specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions__________.

b. The following shall be verified supply fan operating or supply and return fans operating mode is initiated:

(1) All dampers in normal position prior to fan start___________.

(2) All valves in normal position prior to fan start____________.

(3) System safeties allow start if safety conditions are met.____

(4) VAV fan controller shall "soft-start" fan. __________________

(5) Modulate all VAV boxes to minimum air flow and verify that the static pressure does not exceed the high static pressure shutdown setpoint_____________.

(6) Return all VAV boxes to auto _______________.

c. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position. _____________________

(2) Return air damper open. _____________________________________

(3) Relief air damper at minimum position or closed. ___________

(4) Chilled water control valve modulating to maintain leaving air temperature set point. Setpoint _______deg C(F) Actual _____deg C(F)

(5) Fan VAV controller receiving signal from duct static pressure sensor and modulating fan to maintain supply duct static pressure set point.
Setpoint _______kpa(inches-wg) Actual _____kpa(inches-wg)

d. Occupied mode of operation - economizer energized.

(1) Outside air damper modulated to maintain mixed air temperature set point. Setpoint _______deg C(F), Actual _____deg C(F), Outside air damper position ________%.

(2) Relief air damper modulates with outside air damper according to sequence of operation. Relief air damper position_____________%.

(3) Chilled water control valve modulating to maintain leaving air temperature set point. Setpoint _______deg C(F) Actual _____deg C(F)

(4) Hot water control valve modulating to maintain leaving air

temperature set point. Setpoint _______deg C(F) Actual _____deg C(F)

Functional Performance Test Checklist (cont) - Variable Volume Air Handling Unit

(5) Fan VAV controller receives signal from duct static pressure sensor and modulates fan to maintain supply duct static pressure set point. Setpoint kpa(inches-wg)________________ Actual kpa(inches-wg) ___________

e. Unoccupied mode of operation

(1) Observe fan starts when space temperature calls for heating and/or cooling. _________ Note: This does not apply to series boxes.
(2) All dampers in normal position. _____________________________
(3) Verify space temperature is maintained as specified in sequence of operation. _______________

f. The following shall be verified when the supply fan off orsupply and return fans off mode is initiated:

(1) All dampers in normal position. _____________________________

(2) All valves in normal position. ______________________________

(3) Fan de-energizes. ____

g. Verify the chilled water coil control valve operation by setting all VAV's to maximum and minimum cooling.

Max Cooling

Supply air temp. _____ deg C(F) Verify cooling valve operation_______.

Min cooling

Supply air temp. _____ deg C(F) Verify cooling valve operation_______.

h. Verify safety shut down initiated by low temperature protection thermostat. _________

i. Verify occupancy schedule is programmed into time clock/UMCS________.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________

Design Agency Representative ______________________________

Contracting Officer's Representative ______________________________

Using Agency's Representative ______________________________

Functional Performance Test Checklist - Single Zone Air Handling Unit

For Air Handling Unit:

1. Functional Performance Test: Contractor shall verify operation of air handling unit in accordance with specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

b. The following shall be verified when the supply fan operating or supply and return fans operating mode is initiated:

(1) All dampers in normal position prior to fan start___________.

(2) All valves in normal position prior to fan start____________.

(3) System safeties allow start if safety conditions are met. ___

c. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position.______________________

(2) Return air damper open.______________________________________

(3) Relief air damper at minimum position or closed.____________

(4) Chilled water control valve modulating to maintain space cooling temperature set point. Setpoint _______deg C(F) Actual _____deg C(F)

(5) Hot water control valve modulating to maintain space heating temperature set point input from outside air temperature controller. ______

d. Occupied mode of operation - economizer energized.

(1) Outside air damper modulated to maintain mixed air temperature set point. Setpoint _______deg C(F) Actual _____deg C(F) O/A damper position ___________% Return Air Temperature_____deg C(F) Outside Air Temperature _______ deg C(F)

(2) Relief air damper modulates with outside air damper according to sequence of operation. Relief air damper position ________%

(3) Chilled water control valve modulating to maintain space cooling temperature set point. Setpoint _______deg C(F) Actual _____deg C(F) Return sensor overrides to normal operation.

e. Unoccupied mode of operation.

(1) Observe fan starts when space temperature calls for heating/cooling ____.

(2) All dampers in normal position. _________________________

(3) Verify low limit space temperature is maintained as specified in sequence of operation. ______________________________________

Functional Performance Test Checklist (cont) - Single Zone Air Handling Unit

f. The following shall be verified when the supply fan off or supply and return fans off mode is initiated:

(1) All dampers in normal position.______________________________

(2) All valves in normal position._______________________________

(3) Fan de-energizes. ____

g. Verify cooling coil and heating coil operation by varying thermostat set point from cooling set point to heating set point and returning to cooling set point________.

h. Verify safety shut down initiated by low temperature protection thermostat________.

i. Verify occupancy schedule is programmed into time clock/UMCS________.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	____________________________
Contractor's Mechanical Representative	____________________________
Contractor's Electrical Representative	____________________________
Contractor's TAB Representative	____________________________
Contractor's Controls Representative	____________________________
Design Agency Representative	____________________________
Contracting Officer's Representative	____________________________
Using Agency's Representative	____________________________

Functional Performance Test Checklist - Multi-zone Air Handling Unit

For Air Handling Unit:

1. Functional Performance Test: Contractor shall verify operation of air handling unit in accordance with specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

b. The following shall be verified when the supply and return fans operating mode is initiated:

(1) All dampers in normal position. ______________________________

(2) All valves in normal position. _______________________________

(3) System safeties allow start if safety conditions are met. ___

c. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position. ______________________

(2) Return air damper open. ______________________________________

(3) Relief air damper at minimum position or closed. ___________

(4) Chilled water control valve modulating to maintain cold deck supply air temperature set point. Setpoint ______deg C(F) Actual _____deg C (F)

(5) Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. Setpoint _______deg C(F) Actual _____deg C(F) O/A ________deg CF

d. Occupied mode of operation - economizer energized. Note outside air and return air temperature sensors may need to be simulated.

(1) Outside air damper modulates to maintain mixed air temperature set point. Setpoint _______deg C(F) Actual _____deg C(F) Return Air Temperature _______deg C(F) Outside Air Temperature _______deg C(F)

(2) Relief air damper modulates with outside air damper according to sequence of operation.____

(3) Chilled water control valve modulating to maintain cold deck supply air temperature set point. Setpoint ______deg C(F) Actual _____deg C (F)

(4) Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. Setpoint _______deg C(F) Actual _____deg C(F) O/A ______ deg C(F) Return temperature sensors to normal operation.

Functional Performance Test Checklist (cont) - Multi-zone Air Handling Unit

e. Unoccupied mode of operation note time clock and space temperature sensor may require simulation.

(1) Observe fan starts when space temperature calls for heating/cooling.

(2) All dampers in normal position. ___________________________

(3) Verify low limit space temperature is maintained as specified in sequence of operation. _____________________________________

f. The following shall be verified when the supply and return fans off mode is initiated:

(1) All dampers in normal position. ____________________________

(2) All valves in normal position. _____________________________

(3) Fan de-energizes. ____

Note: return time clock and space temperature sensors to normal operation.

g. Verify zone damper operation by varying zone thermostat set points from cooling set point to heating set point and returning to cooling set point. ____

h. Verify safety shut down initiated by low temperature protection thermostat. ____

i. Index room thermostats to full cooling then to full heating. Measure and record cold deck, hot deck, and supply air temperatures and determine damper leakage for a minimum of 2 zones.

Cold deck temperature __________ degrees C(F)
Hot deck temperature __________ degrees C(F)

Zone _______
Zone ____ Supply Air Temperature at Max Cooling _______deg C(F)
Zone ____ Supply Air Temperature at Max Heating _______deg C(F)
Zone ____Hot Deck Damper leakage at Max cooling _______l/S(CFM)
Zone ____Cold Deck Damper leakage at Max heating _______l/S(CFM)

Zone _______
Zone ____ Supply Air Temperature at Max Cooling _______deg C(F)
Zone ____ Supply Air Temperature at Max Heating _______deg C(F)
Zone ____Hot Deck Damper leakage at Max cooling _______l/S(CFM)
Zone ____Cold Deck Damper leakage at Max heating _______l/S(CFM)

j. Verify occupancy schedule is programmed into time clock/UMCS________.

Functional Performance Test Checklist (cont) - Multi-zone Air Handling Unit

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	______________________________
Contractor's Mechanical Representative	______________________________
Contractor's Electrical Representative	______________________________
Contractor's TAB Representative	______________________________
Contractor's Controls Representative	______________________________
Design Agency Representative	______________________________
Contracting Officer's Representative	______________________________
Using Agency's Representative	______________________________

Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller:

1. Functional Performance Test: Contractor shall demonstrate operation of chilled water system in accordance with specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows.

a. Start chilled water pump and establish chilled water flow. Verify chiller-chilled water proof-of-flow switch operation. ____________
Record outdoor air temperature. ____________

b. Verify control system energizes chiller start sequence. ________

c. Verify chiller senses chilled water temperature above set point and control system activates chiller start. Setpoint_____deg C(F) Actual_____ deg C(F)

d. Verify functioning of "soft start" sequence. ___________________

e. Verify and record chiller data in accordance with 2, 3 and 4 below on fully loaded chiller.

f. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed. ____

g. Restart air handling equipment one minute after chiller shut down. Verify chiller restart sequence. ________________________________

2. Verify chiller inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

		DESIGN	TAB TEST	ACTUAL
Chiller inlet pressure	(kPa gauge)	__________	__________	__________
(Chiller inlet pressure	(psig)	__________	__________	__________)
Chiller outlet pressure	(kPa gauge)	__________	__________	__________
(Chiller outlet pressure	(psig)	__________	__________	__________)
Chiller flow	L/sec(GPM)	__________	__________	__________

3. Verify chiller amperage each phase and voltage phase-to-phase and phase-to-ground.

				Motor F/L AMPS
Amperage	Phase 1 __________	Phase 2__________	Phase 3_______	_____
Voltage	Ph1-Ph2 __________	Ph1-Ph3__________	Ph2-Ph3_______	
Voltage	Ph1-gnd __________	Ph2-gnd__________	Ph3-gnd_______	

Functional Performance Test Checklist (cont) - Packaged Air Cooled Chiller

4.

a. Record the following information:

			Design
Outdoor air temperature ________________	degrees C(F)		
Ambient dry bulb temperature ___________	degrees C(F)	_____	degrees C(F)
Entering chilled water temperature _____	degrees C(F)	_____	degrees C(F)
Leaving chilled water temperature ______	degrees C(F)	_____	degrees C(F)

b. Calculate chiller load at ambient conditions and compare to chiller rated capacity from manufacturer's literature. Calculated ________ KWs (Ton) Rated ________ KWs(Ton).

5. Unusual vibration, noise, etc.

____

____

6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________
Design Agency Representative	_____________________________
Contracting Officer's Representative	_____________________________
Using Agency's Representative	_____________________________

Functional Performance Test Checklist - Air Cooled Condensing Unit

For Condensing Unit:

1. Functional Performance Test: Contractor shall demonstrate operation of refrigeration system in accordance with specifications including the following: Start building air handler to provide load for condensing unit. Activate controls system start sequence as follows.

a. Start air handling unit. Verify control system energizes condensing unit start sequence. ____

b. Verify and record data in 2 and 3 below.

c. Shut off air handling equipment to verify condensing unit de-energizes. ____

d. Restart air handling equipment one minute after condensing unit shut down. Verify condensing unit restart sequence. ____________________

2. Verify condensing unit amperage each phase and voltage phase to phase and phase to ground.

Motor Full-Load Amps __________

Amperage	Phase 1 __________	Phase 2__________	Phase 3_______
Voltage	Ph1-Ph2 __________	Ph1-Ph3__________	Ph2-Ph3_______
Voltage	Ph1-gnd __________	Ph2-gnd__________	Ph3-gnd_______

3. Record the following information:

Ambient dry bulb temperature	__________	degrees C(F)
Suction pressure	__________	kPa gauge(psig)
Discharge pressure	__________	kPa gauge(psig)

4. Unusual vibration, noise, etc.

____

____

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________
Design Agency Representative	_____________________________
Contracting Officer's Representative	_____________________________

Using Agency's Representative ________________________________

Functional Performance Test Checklist - Hot Water Boiler

For Boiler:

1. Functional Performance Test: Contractor shall demonstrate operation of hot water system in accordance with specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.

a. Start hot water pump and establish hot water flow. Verify boiler hot water proof-of-flow switch operation. ____________________________
Record outdoor air temperature. ____________________________

b. Verify control system energizes boiler start sequence. _________

c. Verify boiler senses hot water temperature below set point and control system activates boiler start. Setpoint_________deg CF

2. Verify boiler inlet/outlet pressure reading, compare to Test and Balance (TAB) Report, boiler design conditions, and boiler manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Boiler inlet water temperature deg C(F)	_________	_________	_________
Boiler outlet water temperature deg C(F)	_________	_________	_________
Boiler outlet pressure kPa gauge(psig)	_________	_________	_________
Boiler flow rate L/s(gpm)	_________	_________	_________
Flue-gas temperature at boiler outlet deg C(F)		_________	_________
Percent carbon dioxide in flue-gas		_________	_________
Draft at boiler flue-gas exit kpa(inches-wg)		_________	_________
Stack emission pollutants concentration	_________	_________	_________
Fuel type	_________	_________	_________
Combustion efficiency	_________	_________	_________

3. Record the following information:

Ambient dry bulb temperature to determine reset schedule_____degrees C(F)
Building Entering hot water temperature _____degrees C(F)
Building Leaving hot water temperature _____degrees C(F)

4. Verify temperatures in item 3 are in accordance with the reset schedule. ____

5. Verify proper operation of boiler safeties. ________________________
a. Low water_____
b. Water flow____
c. Flame failure____
d. Pilot failure____
e. Pre and Post Purge failure____
f. Pressure relief___
g. High temperature____

6. Shut off building heating equipment to remove load on hot water system. Verify boiler shutdown sequence is initiated and accomplished after load is removed.
____

Functional Performance Test Checklist (cont) - Hot Water Boiler

7. Unusual vibration, noise, etc.

____

____

8. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	______________________________
Contractor's Mechanical Representative	______________________________
Contractor's Electrical Representative	______________________________
Contractor's TAB Representative	______________________________
Contractor's Controls Representative	______________________________
Design Agency Representative	______________________________
Contracting Officer's Representative	______________________________
Using Agency's Representative	______________________________

Functional Performance Test Checklist - Steam Boiler

For Boiler:

1. Functional Performance Test: Contractor shall demonstrate operation of steam heating system in accordance with specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.

a. Start steam heating system. Verify control system energizes boiler start sequence. ______________________________
Record the outdoor air temperature. ______________________________

b. Verify boiler senses steam pressure below set point and control system activates boiler start. ______________________________

c. Shut off building heating equipment to remove load on steam heating system. Verify boiler shutdown sequence is initiated and accomplished after load is removed. ______________________________

d. Verify that water level and makeup water system are operational.
____

2. Verify boiler inlet/outlet pressure reading, compare to boiler design conditions and manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Boiler inlet feedwater temp deg C(F)	________	________	________
Boiler outlet pressure kPa gauge(psig)	________	________	________
Flue-gas temperature at boiler outlet deg C(F)		________	________
Percent carbon dioxide in flue-gas		________	________
Draft at boiler flue-gas exit kpa(inches-wg)		________	________
Stack emission pollutants concentration	________	________	________
Fuel type	________	________	________
Combustion efficiency	________	________	________

3. Record the following information:

Ambient temperature ________ deg C(F)

4. Verify proper operation of boiler safeties.______________________________

5. Unusual vibration, noise, etc.

____

____

6. Visually check refractory for cracks or spalling and refractory and tubes for flame impingement.______________________________

Functional Performance Test Checklist (cont) - Steam Boiler

7. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	______________________________
Contractor's Mechanical Representative	______________________________
Contractor's Electrical Representative	______________________________
Contractor's TAB Representative	______________________________
Contractor's Controls Representative	______________________________
Design Agency Representative	______________________________
Contracting Officer's Representative	______________________________
Using Agency's Representative	______________________________

Functional Performance Test Checklist - Fan Coil Units

The Contracting Officer will select fan coil units to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent. Hot water and chilled water systems must be in operation providing design water temperatures.

1. Functional Performance Test: Contractor shall demonstrate operation of selected fan coils in accordance with specifications including the following:

a. Cooling only fan coils:

(1) Verify fan coil unit response to room temp set point adjustment.
1. Check blower fan airflow. _____ L/s(cfm)
2. Check cooling coil water flow. _____ L/s(gpm)
3. Verify proper operation of cooling water control valve.______
4. Cooling mode inlet air temperature ______deg C(F)
5. Cooling mode outlet air temperature______deg C(F)
6. Calculate coil sensible capacity and compare to design:
Calculated _______Watts(BTU/hr) Design______Watts(BTU/hr)

b. Cooling/heating fan coils:

(1) Verify fan coil unit response to room temp set point adjustment.
1. Check blower fan airflow. _____ L/s(cfm)
2. Check cooling coil water flow. _____ L/s(gpm)
3. Verify proper operation of cooling water control valve. ____
4. Check cooling mode inlet air temperature. _____deg C(F)
5. Check cooling mode outlet air temperature. _____deg C(F)
6. Calculate cooling coil sensible capacity and compare to design:
7. Calculated _________Watts(BTU/hr) Design_____Watts(BTU/hr)
8. Check heating coil water flow. _____ L/s(gpm)
9. Verify proper operation of heating water control valve. _____
10. Check heating mode inlet air temperature. _____ deg C(F)
11. Check heating mode outlet air temperature. _____deg C(F)
12. Calculate heating coil capacity and compare to design:
Calculated______Watts(BTU/hr) design_______Watts(BTU/hr)

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	______________________________
Contractor's TAB Representative	______________________________
Contractor's Controls Representative	_____________________________
Design Agency Representative	_____________________________
Contracting Officer's Representative	_____________________________

Using Agency's Representative ________________________________

Functional Performance Test Checklist - Unit Heaters

The Contracting Officer will select unit heaters to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent. Hot water systems (for hot water unit heaters) must be in operation and supplying design hot water supply temperature water.

1. Functional Performance Test: Contractor shall demonstrate operation of selected unit heaters:

a. Verify unit heater response to room temperature set point adjustment.___________________________________
b. Check heating mode inlet air temperature. _____ deg C(F)
c. Check heating mode outlet air temperature. _____ deg C(F)
d. Record manufacturer's submitted fan capacity _____L/s(cfm)
e. Calculate unit heater capacity using manufacturer's fan capacity and recorded temperatures and compare to design.
f. Calculated_____Watts(BTU/hr) Design______Watts(BTU/hr)

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________
Design Agency Representative	_____________________________
Contracting Officer's Representative	_____________________________
Using Agency's Representative	_____________________________

Functional Performance Test Checklist - Steam/Hot Water Converter

For Converter:

1. Functional Performance Test: Contractor shall demonstrate operation of heating system in accordance with specifications including the following: Start building heating equipment to provide load for converter.

a. Verify control system energizes. ______________________________

b. Verify converter senses hot water temperature below set point and control system modulates steam valve. ____________________________________

c. Shut off building heating equipment to remove load on heating system. Verify converter steam valve closes after load is removed. ______

2. Verify converter inlet/outlet pressure reading, compare to converter design conditions and manufacturer's performance data.

	DESIGN	ACTUAL
Converter inlet water temp deg C(F)	__________	__________
Converter outlet water temp deg C(F)	__________	__________
Converter inlet steam pressure kpa(psig)	__________	__________
Determine water flow rate based on pressure drop through converter L/S(GPM)	__________	__________
Determine water flow rate with flow measuring device L/S(GPM)	__________	__________
	Current Setpoint	Actual Temperature
Verify that temperature of water is in accordance with outdoor air reset schedule	__________	__________

3. Verify proper operation of converter safeties. _____________________

4. Check and report unusual vibration, noise, etc.

____

____

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	____________________________
Contractor's Mechanical Representative	____________________________
Contractor's Electrical Representative	____________________________
Contractor's TAB Representative	____________________________
Contractor's Controls Representative	____________________________
Design Agency Representative	____________________________
Contracting Officer's Representative	____________________________

Using Agency's Representative ______________________________

Functional Performance Test Checklist - Computer Room Unit

For Computer Room Unit:

1. Functional Performance Test: Contractor shall verify operation of computer room unit in accordance with specification including the following:

a. System safeties allow start if safety conditions are met. ______

b. Verify cooling and heating operation by varying thermostat set point from space set point to space set point plus 5.5 (10) degrees, space set point minus 5.5 (10) degrees, and returning to space set point. ________________

c. Verify humidifier operation by varying humidistat set point from space set point to space set point plus 20 percent RH, and returning to space set point.
____

d. Verify that airflow is within tolerance specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.
____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	____________________________
Contractor's Mechanical Representative	_____________________________
Contractor's Electrical Representative	_____________________________
Contractor's TAB Representative	_____________________________
Contractor's Controls Representative	_____________________________
Design Agency Representative	_____________________________
Contracting Officer's Representative	_____________________________
Using Agency's Representative	_____________________________

Functional Performance Test Checklist - HVAC Controls

For HVAC System:

The Contracting Officer will select HVAC control systems to undergo functional performance testing. The number of systems shall not exceed 10 percent. Perform this test simultaneously with FPT for AHU or other controlled equipment.

1. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the Performance Verification Test (PVT) test for that system. Contractor to provide blank PVT test procedures previously done by the controls Contractor.

2. Verify interlock with UMCS system______.

3. Verify all required I/O points function from the UMCS system_____.

4. Certification: We the undersigned have witnessed the Performance Verification Test and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_________________________
Contractor's Mechanical Representative	___________________________
Contractor's Electrical Representative	___________________________
Contractor's TAB Representative	___________________________
Contractor's Controls Representative	___________________________
Design Agency Representative	___________________________
Contractor's Officer's Representative	___________________________
Using Agency's Representative	___________________________

Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System:

1. Functional Performance Test: Contractor shall demonstrate operation of energy recovery system in accordance with specifications including the following: Start equipment to provide energy source for recovery system.

a. Verify energy source is providing recoverable energy.____________

b. Verify recovery system senses available energy and activates.____

2. Verify recovery system inlet/outlet readings, compare to design conditions and manufacturer's performance data.

	Design	Actual
Primary loop inlet temp (degrees C(F))	__________	__________
Primary loop outlet temp (degrees C(F))	__________	__________
Primary loop flow rate L/s(cfm)	__________	__________
Secondary loop inlet temp (degrees C(F))	__________	__________
Secondary loop outlet temp (degrees C(F))	__________	__________
Secondary loop flow rate L/s(cfm)	__________	__________
Primary loop energy Watts(BTU/hr)	__________	__________
Secondary loop energy Watts(BTU/hr)	__________	__________

3. Verify that recovery system deactivates when recoverable energy is no longer available. ____

4. Check and report unusual vibration, noise, etc.

____

____

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	__________________________
Contractor's Mechanical Representative	__________________________
Contractor's Electrical Representative	__________________________
Contractor's TAB Representative	__________________________
Contractor's Controls Representative	__________________________
Design Agency Representative	__________________________
Contractor's Officer's Representative	__________________________
Using Agency's Representative	__________________________

- End of Appendix B -

-End of document

-- End of Section --

SECTION 23 09 23.13 20

BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC
08/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2012; Errata 1 2013; INT 1-9 2013; Errata 2 2013; INT 10-12 2014; Errata 3 2014) BACnet—A Data Communication Protocol for Building Automation and Control Networks

ARCNET TRADE ASSOCIATION (ATA)

ATA 878.1	(1999) Local Area Network: Token Bus

ASME INTERNATIONAL (ASME)

ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC	(2010) Boiler and Pressure Vessels Code

ASTM INTERNATIONAL (ASTM)

ASTM A126	(2004; R 2014) Standard Specification for

	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2013) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.45	(2002; R 2008) Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000v and less)AC Power Circuits

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 8802-3	(2000) Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD)Access Method and Physical Layer Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

UNDERWRITERS LABORATORIES (UL)

UL 1449	(2014) Surge Protective Devices
UL 506	(2008; Reprint Oct 2013) Specialty Transformers
UL 508A	(2013; Reprint Jan 2014) Industrial Control Panels
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment

1.2 DEFINITIONS

1.2.1 ANSI/ASHRAE Standard 135

ANSI/ASHRAE Standard 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks, referred to as "BACnet". ASHRAE developed BACnet to provide a method for diverse building automation devices to communicate and share data over a network.

1.2.2 ARCNET

ATA 878.1 - Attached Resource Computer Network. ARCNET is a deterministic LAN technology; meaning it's possible to determine the maximum delay before a device is able to transmit a message.

1.2.3 BACnet

Building Automation and Control Network; the common name for the communication standard ASHRAE 135. The standard defines methods and protocol for cooperating building automation devices to communicate over a variety of LAN technologies.

1.2.4 BACnet/IP

An extension of BACnet, Annex J, defines this mechanism using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number. See also "BACnet Broadcast Management Device".

1.2.5 BACnet Internetwork

Two or more BACnet networks, possibly using different LAN technologies, connected with routers. In a BACnet internetwork, there exists only one message path between devices.

1.2.6 BACnet Network

One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.

1.2.7 BACnet Segment

One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

1.2.8 BBMD

BACnet Broadcast Management Device (BBMD). A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Every IP subnetwork that is part of a BACnet/IP network must have only one BBMD. See also "BACnet/IP".

1.2.9 BAS

Building Automation Systems, including DDC (Direct Digital Controls) used for facility automation and energy management.

1.2.10 BAS Owner

The regional or local user responsible for managing all aspects of the BAS operation, including: network connections, workstation management, submittal review, technical support, control parameters, and daily operation.

1.2.11 BIBBs

BACnet Interoperability Building Blocks. A collection of BACnet services used to describe supported tasks. BIBBs are often described in terms of "A" (client) and "B" (server) devices. The “A” device uses data provided by the "B" device, or requests an action from the “B” device.

1.2.12 BI

BACnet International, formerly two organizations: the BACnet Manufacturers Association (BMA) and the BACnet Interest Group - North America (BIG-NA).

1.2.13 BI/BTL

BACnet International/BACnet Testing Laboratories (Formerly BMA/BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

1.2.14 Bridge

Network hardware that connects two or more network (or BACnet internetwork) segments at the physical and data link layers. A bridge may also filter messages.

1.2.15 Broadcast

A message sent to all devices on a network segment.

1.2.16 Device

Any control system component, usually a digital controller, that contains a BACnet Device Object and uses BACnet to communicate with other devices. See also "Digital Controller".

1.2.17 Device Object

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

1.2.18 Device Profile

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE Standard 135-2004, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing BIBBs supported.

1.2.19 Digital Controller

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions. In most cases, synonymous with a BACnet device described in this specification. See also "Device".

1.2.20 Direct Digital Control (DDC)

Digital controllers performing control logic. Usually the controller directly senses physical values, makes control decisions with internal programs, and outputs control signals to directly operate switches, valves, dampers, and motor controllers.

1.2.21 DDC System

A network of digital controllers, communication architecture, and user interfaces. A DDC system may include programming, sensors, actuators, switches, relays, factory controls, operator workstations, and various other devices, components, and attributes.

1.2.22 Ethernet

A family of local-area-network technologies providing high-speed networking features over various media.

1.2.23 Firmware

Software programmed into read only memory (ROM), flash memory, electrically erasable programmable read only memory (EEPROM), or erasable programmable read only memory (EPROM) chips.

1.2.24 Gateway

Communication hardware connecting two or more different protocols, similar to human language translators. The Gateway translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

1.2.25 Half Router

A device that participates as one partner in a BACnet point-to-point (PTP) connection. Two half-routers in an active PTP connection combine to form a single router.

1.2.26 Hub

A common connection point for devices on a network.

1.2.27 Internet Protocol (IP, TCP/IP, UDP/IP)

A communication method, the most common use is the World Wide Web. At the lowest level, it is based on Internet Protocol (IP), a method for conveying and routing packets of information over various LAN media. Two common protocols using IP are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP). UDP conveys information to well-known "sockets" without confirmation of receipt. TCP establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.2.28 Input/Output (I/O)

Physical inputs and outputs to and from a device, although the term sometimes describes software, or "virtual" I/O. See also "Points".

1.2.29 I/O Expansion Unit

An I/O expansion unit provides additional point capacity to a digital controller.

1.2.30 IP subnet

Internet protocol (IP) identifies individual devices with a 32-bit number divided into four groups from 0 to 255. Devices are often grouped and share some portion of this number. For example, one device has IP address 209.185.47.68 and another device has IP address 209.185.47.82. These two devices share Class C subnet 209.185.47.00

1.2.31 Local-Area Network (LAN)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.2.32 LonTalk

CEA-709.1-D. A communication protocol developed by Echelon Corp. LonTalk is an optional physical and data link layer for BACnet.

1.2.33 MAC Address

Media Access Control address. The physical node address that identifies a device on a Local Area Network.

1.2.34 Master-Slave/Token-Passing (MS/TP)

ISO 8802-3. One of the LAN options for BACnet. MSTP uses twisted-pair wiring for relatively low speed and low cost communication (up to 4,000 ft at 76.8K bps).

1.2.35 Native BACnet Device

A device that uses BACnet as its primary, if not only, method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

1.2.36 Network

Communication technology for data communications. BACnet approved network types are BACnet over Internet Protocol (IP), Point to Point (PTP) Ethernet, ARCNET, MS/TP, and LonTalk®.

1.2.37 Network Number

A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

1.2.38 Object

The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

1.2.39 Object Identifier

An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

1.2.40 Object Properties

Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

1.2.41 Peer-to-Peer

Peer-to-peer refers to devices where any device can initiate and respond to communication with other devices.

1.2.42 Performance Verification Test (PVT)

The procedure for determining if the installed BAS meets design criteria prior to final acceptance. The PVT is performed after installation, testing, and balancing of mechanical systems. Typically the PVT is performed by the Contractor in the presence of the Government.

1.2.43 PID

Proportional, integral, and derivative control; three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems (leaving "PI" control).

1.2.44 PICS

Protocol Implementation Conformance Statement (PICS), describing the BACnet capabilities of a device. See BACnet, Annex A for the standard format and content of a PICS statement.

1.2.45 Points

Physical and virtual inputs and outputs. See also "Input/Output".

1.2.46 PTP

Point-to-Point protocol connects individual BACnet devices or networks using serial connections like modem-to-modem links.

1.2.47 Repeater

A network component that connects two or more physical segments at the physical layer.

1.2.48 Router

A BACnet router is a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

1.2.49 Stand-Alone Control

Refers to devices performing equipment-specific and small system control without communication to other devices or computers for physical I/O, excluding outside air and other common shared conditions. Devices are located near controlled equipment, with physical input and output points limited to 64 or less per device, except for complex individual equipment or systems. Failure of any single device will not cause other network devices to fail. BACnet "Smart" actuators (B-SA profile) and sensors (B-SS profile) communicating on a network with a parent device are exempt from stand-alone requirements.

1.3 SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph entitled "Subcontractor Special Requirements" in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS. The paragraph specifies that all contract requirements of this section shall be accomplished directly by a first tier subcontractor. No work required shall be accomplished by a second tier subcontractor.

1.4 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC DESCRIPTION

a. Remove existing, provide new BACnet, modify existing and/or merge with existing non-BACnet and BACnet DDC systems including associated equipment and accessories, as indicated on contract drawings and specification. All new devices are accessible using a Web browser interface and communicate using ASHRAE 135 BACnet communications without the use of gateways, unless gateways are shown on the design drawings and specifically requested by the Government. Where gateways are allowed, they must support ASHRAE 135, including all object properties and read-write services shown on Government approved interoperability schedules. Manufacturer's products, including design, materials, fabrication, assembly, inspection, and testing shall be in accordance with ASHRAE 135, ASME B31.1, and NFPA 70, except where indicated otherwise.

b. The existing DDC system is manufactured by company indicated on drawings. The server and operator workstation are located as indicated on drawings. If installing a system made by the same manufacturer, upgrade or replace the existing server, operator workstation, and laptop computer software with the manufacturer's latest software version for all used applications. Upgrade hardware, memory, and operating systems if required.

1.4.1 Design Requirements

1.4.1.1 Control System Drawings Title Sheet

Provide a title sheet for the control system drawing set. Include the project title, project location, contract number, the controls contractor preparing the drawings, an index of the control drawings in the set, and a legend of the symbols and abbreviations used throughout the control system drawings.

1.4.1.2 List of I/O Points

Also known as a Point Schedule, provide for each input and output point physically connected to a digital controller: point name, point description, point type (Analog Output (AO), Analog Input (AI), Binary Output (BO), Binary Input (BI)), point sensor range, point actuator range, point address, BACnet object, associated BIBBS (where applicable), and point connection terminal number. Typical schedules for multiple identical equipment are allowed unless otherwise requested in design or contract criteria.

1.4.1.3 Control System Components List

Provide a complete list of control system components installed on this project. Include for each controller and device: control system schematic name, control system schematic designation, device description, manufacturer, and manufacturer part number. For sensors, include point name, sensor range, and operating limits. For valves, include body style, Cv, design flow rate, pressure drop, valve characteristic (linear or equal percentage), and pipe connection size. For actuators, include point name, spring or non-spring return, modulating or two-position action, normal (power fail) position, nominal control signal operating range (0-10 volts DC or 4-20 milliamps), and operating limits.

1.4.1.4 Control System Schematics

Provide control system schematics. Typical schematics for multiple identical equipment are allowed unless otherwise requested in design or contract criteria. Include the following:

a. Location of each input and output device

b. Flow diagram for each piece of HVAC equipment

c. Name or symbol for each control system component, such as V-1 for a valve

d. Setpoints, with differential or proportional band values

e. Written sequence of operation for the HVAC equipment

f. Valve and Damper Schedules, with normal (power fail) position

1.4.1.5 HVAC Equipment Electrical Ladder Diagrams

Provide HVAC equipment electrical ladder diagrams. Indicate required electrical interlocks.

1.4.1.6 Component Wiring Diagrams

Provide a wiring diagram for each type of input device and output device. Indicate how each device is wired and powered; showing typical connections at the digital controller and power supply. Show for all field connected devices such as control relays, motor starters, actuators, sensors, and transmitters.

1.4.1.7 Terminal Strip Diagrams

Provide a diagram of each terminal strip. Indicate the terminal strip location, termination numbers, and associated point names.

1.4.1.8 BACnet Communication Architecture Schematic

Provide a schematic showing the project's entire BACnet communication network, including addressing used for LANs, LAN devices including routers and bridges, gateways, controllers, workstations, and field interface devices. If applicable, show connection to existing networks.

1.5 SUBMITTALS

Submit detailed and annotated manufacturer's data, drawings, and specification sheets for each item listed, that clearly show compliance with the project specifications.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following according to 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Include the following in the project's control system drawing set:

Control system drawings title sheet; G

List of I/O Points; G

Control System Components List; G

Control system schematics; G

HVAC Equipment Electrical Ladder diagrams; G

Component wiring diagrams; G

Terminal strip diagrams; G

BACnet communication architecture schematic; G

SD-03 Product Data

Direct Digital Controllers; G

Include BACnet PICS for each controller/device type, including smart sensors (B-SS) and smart actuators (B-SA).

BACnet Gateways; G

Include BACnet and workstation display information; bi-directional communication ability; compliance with interoperability schedule; expansion capacity; handling of alarms, events, scheduling and trend data; and single device capability (not depending on multiple devices for exchanging information from either side of the gateway).

BACnet Protocol Analyzer; G

Include capability to store and report data traffic on BACnet networks, measure bandwidth usage, filter information, and identify BACnet devices.

DDC Software; G

BACnet Operator Workstation; G

BACnet Operator Workstation DDC Software; G

Include BACnet PICS for Operator Workstation software.

Notebook Computer; G

Sensors and Input Hardware; G

Output Hardware; G

Surge and transient protection; G

Indicators; G

Air compressors; G

Refrigerated air dryers; G

Pneumatic tubing; G

Duct smoke detectors; G

Variable frequency (motor) drives; G

SD-05 Design Data

Performance Verification Testing Plan; G

Pre-Performance Verification Testing Checklist; G

SD-06 Test Reports

Performance Verification Testing Report; G

SD-07 Certificates

Contractor's Qualifications; G

SD-09 Manufacturer's Field Reports

Pre-PVT Checklist; G

SD-10 Operation and Maintenance Data

Comply with requirements for data packages in Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as supplemented and modified in this specification.

BACnet Direct Digital Control Systems, Data Package 4; G

Controls System Operators Manuals, Data Package 4; G

VFD Service Manuals, Data Package 4; G

SD-11 Closeout Submittals

Training documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Standard Products

Provide material and equipment that are standard manufacturer's products currently in production and supported by a local service organization.

1.6.2 Delivery, Storage, and Handling

Handle, store, and protect equipment and materials to prevent damage before and during installation according to manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6.3 Operating Environment

Protect components from humidity and temperature variation, dust, and contaminants. If components are stored before installation, keep them within the manufacturer's limits.

1.6.4 Finish of New Equipment

New equipment finishing shall be factory provided. Manufacturer's standard factory finishing shall be proven to withstand 125 hours in a salt-spray fog test. Equipment located outdoors shall be proven to withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be according to ASTM B117, with acceptance criteria as follows: immediately after completion of the test, the finish shall show no signs of degradation or loss of adhesion beyond 3.175 mm (0.125 inch) on either side of the scratch mark.

1.6.5 Verification of Dimensions

The contractor shall verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing work.

1.6.6 Contractor's Qualifications

Submit documentation certifying the controls Contractor performing the work has completed at least three DDC systems installations of a similar design to this project, and programmed similar sequences of operation for at least two years.

1.6.7 Modification of References

The advisory provisions in ASME B31.1 and NFPA 70 are mandatory. Substitute "shall" for "should" wherever it appears and interpret all references to the "authority having jurisdiction" and "owner" to mean the Contracting Officer.

1.6.8 Project Sequence

The control system work for this project shall proceed in the following order:

a. Submit and receive approval on the Shop Drawings, Product Data, and Certificates specified under the paragraph entitled "SUBMITTALS."

b. Perform the control system installation work, including all field check-outs and tuning.

c. Provide support to TAB personnel as specified under the paragraph "TEST AND BALANCE SUPPORT."

d. Submit and receive approval of the Controls System Operators Manual specified under the paragraph "CONTROLS SYSTEM OPERATORS MANUALS."

e. Submit and receive approval of the Performance Verification Testing Plan and the Pre-PVT Checklist specified under the paragraph "PERFORMANCE VERIFICATION TESTING."

f. Perform the Performance Verification Testing.

g. Submit and receive approval on the PVT Report.

h. Submit and receive approval on the Training Documentation specified under the paragraph "INSTRUCTION TO GOVERNMENT PERSONNEL" and "VFD Service Support". Submit at least 30 days before training.

i. Deliver the final Controls System Operators Manuals and VFD Service Manuals.

j. Conduct the Phase I Training and VFD on-site/hands-on training.

k. Conduct the Phase II Training.

l. Submit and receive approval of Closeout Submittals.

PART 2 PRODUCTS

2.1 DDC SYSTEM

a. Provide a networked DDC system for stand-alone control in compliance with the latest revision of the ASHRAE 135 BACnet standard. Include all programming, objects, and services required to meet the sequence of control. Provide BACnet communications between the DDC system and native BACnet devices furnished with HVAC equipment and plant equipment including boilers, chillers, and variable frequency drives. Devices provided shall be certified in the BACnet Testing Laboratories (BTL) Product Listing.

b. Provide an operator workstation and new server with complete interface software capable of programming, configuring, and monitoring the digital controllers. Interface the new DDC system with the site's existing server and operator workstation and software including graphic creation, scheduling, alarming, and trending. The server and workstation are located as indicated on drawings.

2.1.1 Direct Digital Controllers

Direct digital controllers shall be UL 916 rated.

2.1.1.1 I/O Point Limitation

The total number of I/O hardware points used by a single stand-alone digital controller, including I/O expansion units, shall not exceed 64, except for complex individual equipment or systems. Place I/O expansion units in the same cabinet as the digital controller.

2.1.1.2 Environmental Limits

Controllers shall be suitable for, or placed in protective enclosures suitable for the environment (temperature, humidity, dust, and vibration) where they are located.

2.1.1.3 Stand-Alone Control

Provide stand-alone digital controllers.

2.1.1.4 Internal Clock

Provide internal clocks for all BACnet Building Controllers (B-BC) and BACnet Advanced Application Controllers (B-AAC) using BACnet time synchronization services. Automatically synchronize system clocks daily from an operator-designated controller. The system shall automatically adjust for daylight saving time.

2.1.1.5 Memory

Provide sufficient memory for each controller to support the required control, communication, trends, alarms, and messages. Protect programs residing in memory with EEPROM, flash memory, or by an uninterruptible power source (battery or uninterruptible power supply). The backup power source shall have capacity to maintain the memory during a 72-hour continuous power outage. Rechargeable power sources shall be constantly charged while the controller is operating under normal line power. Batteries shall be replaceable without soldering. Trend and alarm history collected during normal operation shall not be lost during power outages less than 72 hours long.

2.1.1.6 Immunity to Power Fluctuations

Controllers shall operate at 90 percent to 110 percent nominal voltage rating.

2.1.1.7 Transformer

The controller power supply shall be fused or current limiting and rated at 125 percent power consumption.

2.1.1.8 Wiring Terminations

Use screw terminal wiring terminations for all field-installed controllers. Provide field-removable modular terminal strip or a termination card connected by a ribbon cable for all controllers other than terminal units.

2.1.1.9 Input and Output Interface

Provide hard-wired input and output interface for all controllers as follows:

a. Protection: Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with sources up to 24 volts AC or DC for any duration shall cause no controller damage.

b. Binary Inputs: Binary inputs shall have a toggle switch and monitor on and off contacts from a "dry" remote device without external power, and external 5-24 VDC voltage inputs.

c. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and accumulate pulses at a resolution suitable to the application.

d. Analog Inputs: Analog inputs shall monitor low-voltage (0-10 VDC), current (4-20 mA), or resistance (thermistor or RTD) signals.

e. Binary Outputs: Binary outputs shall have a toggle switch and send a pulsed 24 VDC low-voltage signal for modulation control, or provide a maintained open-closed position for on-off control. For HVAC equipment and plant controllers, provide for manual overrides, either with three-position (on-off-auto) override switches and status lights, or with an adjacent operator display and interface. Where appropriate, provide a method to select normally open or normally closed operation.

f. Analog Outputs: Analog outputs shall send modulating 0-10 VDC or 4-20 mA signals to control output devices.

g. Tri-State Outputs: Tri-State outputs shall provide three-point floating control of terminal unit electronic actuators.

2.1.1.10 Digital Controller BACnet Internetwork

Provide a BACnet internetwork with control products, communication media, connectors, repeaters, hubs, and routers. Provide intermediate gateways, only when requested by the Government and shown on the contract drawings, to connect existing non-BACnet devices to the BACnet internetwork. Controller and operator interface communication shall conform to ASHRAE 135, BACnet. Use the building's existing Ethernet backbone for network segments marked "existing" on project drawings. Coordinate connections to existing Ethernet backbones with the BAS Owner and LAN administrator. If a controller becomes non-responsive, the remaining controllers shall continue operating and not be affected by the failed controller.

2.1.1.11 Communications Ports

a. Direct-Connect Interface Ports: Provide at least one extra communication port at each local BACnet network for direct connecting a notebook computer or BACnet hand-held terminal so all network BACnet objects and properties may be viewed and edited by the operator.

b. Telecommunications Interface Port: Provide one telecommunication port per building, permitting remote communication via point-to-point (PTP) protocol over telephone lines.

2.1.1.12 Modems

Provide v.92 or DSL modems where required for communication between the BACnet Operator Workstation (B-OWS) and the DDC system.

2.1.1.13 BACnet Gateways

Provide BACnet communication ports, whenever available as a plant equipment OEM standard option, for DDC integration via a single communication cable. Typical BACnet controlled plant equipment includes, but is not limited to, boilers, chillers, and variable frequency motor drives.

Provide gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC controlled plant equipment, only when specifically requested and approved by the Government, and shown on the Government approved BACnet Communication Architecture Schematic. Provide with each gateway an interoperability schedule Use gateway interoperability schedules shown on design drawings or other project documents, showing each point or event on the legacy side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (BIBBS), defined in ASHRAE 135 Annex K. Provide two-year minimum warranty for each gateway, including parts and labor.

The following minimum capabilities are required:

a. Gateways shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.

b. Gateways shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.

c. Gateways shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.

d. Gateways shall meet the requirements of Data Sharing Read Property (DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management Dynamic Device Binding-B (DM-DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with ASHRAE 135.

e. Gateways shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.1.1.14 Digital Controller Cabinet

Provide each digital controller in a factory fabricated cabinet enclosure. Cabinets located indoors shall protect against dust and have a minimum NEMA 1 rating, except where indicated otherwise. Cabinets located outdoors or in damp environments shall protect against all outdoor conditions and have a minimum NEMA 4 rating. Outdoor control panels and controllers must be able to withstand extreme ambient conditions, without malfunction or failure, whether or not the controlled equipment is running. If necessary, provide a thermostatically controlled panel heater in freezing locations, and an internal ventilating fan in locations exposed to direct sunlight. Cabinets shall have a hinged lockable door and an offset removable metal back plate, except controllers integral with terminal units, like those mounted on VAV boxes. Provide like-keyed locks for all hinged panels provided and a set of two keys at each panel, with one key inserted in the lock.

2.1.1.15 Main Power Switch and Receptacle

Provide each control cabinet with a main external power on/off switch located inside the cabinet. Also provide each cabinet with a separate 120 VAC duplex receptacle.

2.1.2 DDC Software

2.1.2.1 Programming

Provide programming to execute the sequence of operation indicated. Provide all programming and tools to configure and program all controllers. Provide programming routines in simple, easy-to-follow logic with detailed text comments describing what the logic does and how it corresponds to the project's written sequence of operation.

a. Graphic-based programming shall use a library of function blocks made from pre-programmed code designed for BAS control. Function blocks shall be assembled with interconnecting lines, depicting the control sequence in a flowchart. If providing a computer with device programming tools as part of the project, graphic programs shall be viewable in real time showing present values and logical results from each function block.

b. Menu-based programming shall be done by entering parameters, definitions, conditions, requirements, and constraints.

c. For line-by-line and text-based programming, declare variable types (local, global, real, integer, etc.) at the beginning of the program. Use descriptive comments frequently to describe the programming.

d. If providing a computer with device programming tools as part of the project, provide a means for detecting program errors and testing software strategies with a simulation tool. Simulation may be inherent within the programming software suite, or provided by physical controllers mounted in a NEMA 1 test enclosure. The test enclosure shall contain one dedicated controller of each type provided under this contract, complete with power supply and relevant accessories.

2.1.2.2 Parameter Modification

All writeable object properties, and all other programming parameters needed to comply with the project specification shall be adjustable for devices at any network level, including those accessible with web-browser communication, and regardless of programming methods used to create the applications.

2.1.2.3 Short Cycling Prevention

Provide setpoint differentials and minimum on/off times to prevent equipment short cycling.

2.1.2.4 Equipment Status Delay

Provide an adjustable delay from when equipment is commanded on or off and when the control program looks to the status input for confirmation.

2.1.2.5 Run Time Accumulation

Use the Elapsed Time Property to provide re-settable run time accumulation for each Binary Output Object connected to mechanical loads greater than 1 HP, electrical loads greater than 10 KW, or wherever else specified.

2.1.2.6 Timed Local Override

Provide an adjustable override time for each push of a timed local override button.

2.1.2.7 Time Synchronization

Provide time synchronization, including adjustments for leap years, daylight saving time, and operator time adjustments.

2.1.2.8 Scheduling

Provide operating schedules as indicated, with equipment assigned to groups. Changing the schedule of a group shall change the operating schedule of all equipment in the group. Groups shall be capable of operator creation, modification, and deletion. Provide capability to view and modify schedules in a seven-day week format. Provide capability to enter holiday and override schedules one full year at a time.

2.1.2.9 Object Property Override

Allow writeable object property values to accept overrides to any valid value. Where specified or required for the sequence of control, the Out-Of-Service property of Objects shall be modifiable using BACnet's write property service. When documented, exceptions to these requirement are allowed for life, machine, and process safeties.

2.1.2.10 Alarms and Events

Alarms and events shall be capable of having programmed time delays and high-low limits. When a computer workstation or web server is connected to the BACnet internetwork, alarms/events shall report to the computer, printer, alphanumeric pager, e-mail, or cell phone, as defined by an authorized operator. Otherwise alarms/events shall be stored within a device on the BACnet network until connected to a user interface device and retrieved. Provide alarms/events in agreement with the point schedule, sequence of operation, and the BAS Owner. At a minimum, provide programming to initiate alarms/events any time a piece of equipment fails to operate, a control point is outside normal range or condition shown on schedules, communication to a device is lost, a device has failed, or a controller has lost its memory.

2.1.2.11 Trending

Provide BACnet trend services capable of trending all object present values set points, and other parameters indicated for trending on project schedules. Trends may be associated into groups, and a trend report may be set up for each group. Trends are stored within a device on the BACnet network, with operator selectable trend intervals from 10 seconds up to 60 minutes. The minimum number of consecutive trend values stored at one time shall be 100 per variable. When trend memory is full, the most recent data shall overwrite the oldest data.

The operator workstation shall upload trends automatically upon reaching 3/4 of the device buffer limit (via Notification_Threshold property), by operator request, or by time schedule for archiving. Archived and real-time trend data shall be available for viewing numerically and graphically for at the workstation and connected notebook computers.

2.1.2.12 Device Diagnostics

Each controller shall have diagnostic LEDs for power, communication, and device fault condition. The DDC system shall recognize and report a non-responsive controller.

2.1.2.13 Power Loss

Upon restoration of power, the DDC system shall perform an orderly restart and restoration of control.

2.1.3 BACnet Operator Workstation

The workstation shall be capable of accessing all DDC system devices and communicate using the BACnet protocol. The workstation shall be capable of displaying, modifying, creating, archiving, and deleting (as applicable): all points, objects, object properties, programming, alarms, trends, messages, schedules, and reports.

2.1.3.1 BACnet Operator Workstation Hardware

Configure according to system manufacturer's specifications and conforming to BACnet Operator Workstation (B-OWS) device standards found in ASHRAE 135, Annex L. Install to permit complete monitoring and troubleshooting of the DDC system.

At a minimum the workstation hardware shall include: a desktop personal computer with most current Professional version of Microsoft Windows operating system or equal, processor and RAM exceeding capability and speed required by operating system and application software, hard drive capacity exceeding software and yearly archive requirements, 16X internal DVD+/-R/RW/CD-RW drive with archive creator software, external 200 GB USB 2.0 hard drive and cable, 4 USB 2.0 ports, 10/100 network interface card, MS/TP card, 19-inch LCD monitor, internal V.92 modem, sound card with speakers, 101 character keyboard, optical mouse, USB Hub with four USB 2.0 ports and connecting cable, laser printer with USB port and cable, 3 matching toner cartridges, 120-volt 800 VA uninterruptible power supply with automatic voltage regulation and 4 minimum battery back-up outlets and 2 surge protected outlets, Microsoft Office bundled software, Adobe Acrobat pro, and Symantec Ghost disk imaging software or equal. Provide all original licenses, installation media, documentation, and recovery CDs capable of restoring the original configuration. Provide a manufacturer's 3-year next business day on-site warranty with the Government listed as the warranty owner.

2.1.3.2 Password Protection

Provide at least five levels of password protection for operator interfaces. The lowest level only allow viewing graphics. The second level allows viewing graphics and changing space temperature setpoints. The third level allows the previous level's capability, plus changing operating schedules. The fourth level allows access to all functions except passwords. The highest level provides all administrator rights and allows full access to all programming, including setting new passwords and access levels. Provide the BAS Owner with the highest level password access. Provide automatic log out if no keyboard or mouse activity is detected after a user-defined time delay.

2.1.3.3 BACnet Operator Workstation DDC Software

Provide the workstation software with the manufacturer's installation CDs and licenses. Configure the software according to the DDC system manufacturer's specifications and in agreement with BACnet Operator Workstation (B-OWS) device standards found in ASHRAE 135, Annex L.

The workstation software shall permit complete monitoring, modification, and troubleshooting interface with the DDC system. The operator interface with the software shall be menu-driven with appropriate displays and menu commands to manipulate the DDC system's objects, point data, operating schedules, control routines, system configuration, trends, alarms, messages, graphics, and reports. Trends shall be capable of graphic display in real time, with variables plotted as functions of time. Each alarmed point shall be capable of displaying its alarm history, showing when it went into alarm, if and when it was acknowledged, and when it went out of alarm. The modification of DDC system parameters and object properties shall be accomplished with "fill in the blank" and/or "point and drag" methods. Modifications shall download to the appropriate controllers at the operator's request.

2.1.3.4 Graphics Software

Provide web-based system graphics viewable on browsers compatible with MS Internet Explorer 6.X or greater using an industry-standard file format such as HTML, BMP, JPEG, or GIF.

Graphic displays shall have full-screen resolution when viewed on the workstation and notebook computers. Dynamic data on graphics pages shall refresh within 10 seconds using an Internet connection, or 30 seconds using a dial-up modem connection. Graphics viewing shall not require additional "plug-in" software like Java, Shockwave and Flash applications unless the software is readily available for free over the Internet, and certified for use with Navy Marine Corps Internet (NMCI) personal computers.

The graphics shall show the present value and object name for each of the project's I/O points on at least one graphic page. Arrange point values and names on the graphic displays in their appropriate physical locations with respect to the floor plan or equipment graphic displayed. Graphics shall allow the operator to monitor current status, view zone and equipment summaries, use point-and-click navigation between graphic pages, and edit setpoints and parameters directly from the screens. Items in alarm shall be displayed using a different color or other obvious visual indicator.
Provide graphics with the following:

a. Graphic Types: Provide at least one graphic display for each piece of HVAC equipment, building floor, and controlled zone. Indicate dynamic point values, operating statuses, alarm conditions, and control setpoints on each display. Provide summary pages where appropriate.

(1) Building Elevation: For buildings more than one story, provide an elevation view of the building with links to each of the building's floor plans. Simulate the building's architecture and include the building number and floor numbers. If possible, use an actual photograph of the building.

(2) Building Floor Plans: Provide a floor plan graphic for each of the building's floors and roof with dynamic display of space temperature and other important data. If used, indicate and provide links to sub-plan areas. If possible, use the project's electronic drawing files for the graphic backgrounds. Provide clear names for important areas, such as "Main Conference Room." Include room names and numbers where applicable. Include features such as stairwells, elevators, and main entrances. Where applicable, include the mechanical room, HVAC equipment, and control component locations, with corresponding links to the equipment graphics.

(3) Sub-plan Areas: Where a building's floor plan is too large to adequately display on the screen, sub-divide the plan into distinct areas, and provide a separate graphic display for each area. Provide same level of detail requested in building floor plan section above.

(4) HVAC Equipment: Provide a graphic display for each piece of HVAC equipment, such as a fan coil unit, VAV terminal, or air handling unit. Equipment shall be represented by a two or three-dimensional drawing. Where multiple pieces of equipment combine to form a system, such as a central chiller plant or central heating plant, provide one graphic to depict the entire plant. Indicate the equipment, piping, ductwork, dampers, and control valves in the installed location. Include labels for equipment, piping, ductwork, dampers, and control valves. Show the direction of air and water flow. Include dynamic display of applicable object data with clear names in appropriate locations.

(5) Sequence of Operation: Provide a graphic screen displaying the written out full sequence of operation for each piece of HVAC equipment. Provide a link to the sequence of operation displays on their respective equipment graphics. Include dynamic real-time data within the text for setpoints and variables.

b. Graphic Title: Provide a prominent, descriptive title on each graphic page.

c. Dynamic Update: When the workstation is on-line, all graphic I/O object values shall update with change-of-value services, or by operator selected discrete intervals.

d. Graphic Linking: Provide forward and backward linking between floor plans, sub-plans, and equipment.

e. Graphic Editing: Provide installed software to create, modify, and delete the DDC graphics. Include the ability to store graphic symbols in a symbol directory and import these symbols into the graphics.

f. Dynamic Point Editing: Provide full editing capability for deleting, adding, and modifying dynamic points on the graphics.

2.1.4 Notebook Computer

Provide a notebook computer, complete with the project's installed DDC software, applications database, and graphics to fully troubleshoot and program the project's devices. Notebook computers for web-based systems do not require this installed software if they have the ability to connect locally in real time, view all graphics, and fully troubleshoot, modify, and program all project devices. Provide the notebook computer with ballistic nylon carrying case with shoulder strap with all necessary cables and interface hardware needed for setup and communication with the controllers and control system components.

At a minimum the notebook computer shall include: most current version of Microsoft Windows operating system, processor with capability and speed required by application software, 200 giga-byte hard drive, 8 giga-byte RAM, 2 USB 2.0 ports, 10/100 network interface card,ARCnet card, MS/TP card, internal V.92 modem, 15-inch display, keyboard, 3-hour battery with charger, 52X internal CD-RW drive with CD creator software, and Microsoft Office bundled software. Provide all original licenses, installation media, documentation, and recovery CDs capable of restoring the original configuration. Provide the manufacturer's 3-year next business day on-site warranty with the Government listed as the warranty owner.

2.1.5 BACnet Protocol Analyzer

Provide a BACnet protocol analyzer and required cables and fittings for connection to the BACnet network. The analyzer shall include the following minimum capabilities:

a. Capture and store to a file data traffic on all network levels.

b. Measure bandwidth usage.

c. Filtering options with ability to ignore select traffic.

2.2 SENSORS AND INPUT HARDWARE

Coordinate sensor types with the BAS Owner to keep them consistent with existing installations.

2.2.1 Field-Installed Temperature Sensors

Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless absolutely necessary.

2.2.1.1 Thermistors

Precision thermistors may be used in applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between 32 to 150 degrees F. Stability error of the thermistor over five years shall not exceed 0.25 degrees F cumulative. A/D conversion resolution error shall be kept to 0.1 degrees F. Total error for a thermistor circuit shall not exceed 0.5 degrees F.

2.2.1.2 Resistance Temperature Detectors (RTDs)

Provide RTD sensors with platinum elements compatible with the digital controllers. Encapsulate sensors in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1

percent (1 ohm) of expected ohms (1000 ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degrees F cumulative. Direct connection of RTDs to digital controllers without transmitters is preferred. When RTDs are connected directly, lead resistance error shall be less than 0.25 degrees F. The total error for a RTD circuit shall not exceed 0.5 degrees F.

2.2.1.3 Temperature Sensor Details

a. Room Type: Provide the sensing element components within a decorative protective cover suitable for surrounding decor. Provide room temperature sensors with timed override button, setpoint adjustment lever, digital temperature display. Provide a communication port or 802.11x wireless support for a portable operator interface like a notebook computer or PDA.

b. Duct Probe Type: Ensure the probe is long enough to properly sense the air stream temperature.

c. Duct Averaging Type: Continuous averaging sensors shall be one foot in length for each 4 square feet of duct cross-sectional area, and a minimum length of 6 feet.

d. Pipe Immersion Type: Provide minimum three-inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel when used in steel piping, and brass when used in copper piping. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior.

e. Outside Air Type: Provide the sensing element on the building's north side with a protective weather shade that positions the sensor approximately 3 inches off the wall surface, does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain.

2.2.2 Transmitters

Provide transmitters with 4 to 20 mA or 0 to 10 VDC linear output scaled to the sensed input. Transmitters shall be matched to the respective sensor, factory calibrated, and sealed. Size transmitters for an output near 50 percent of its full-scale range at normal operating conditions. The total transmitter error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 12 to 24 volts AC or DC. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter drift shall not exceed 0.03 degrees F a year.

2.2.2.1 Relative Humidity Transmitters

Provide transmitters with an accuracy equal to plus or minus 2 percent from 0 to 90 percent scale, and less than one percent drift per year. Sensing elements shall be the polymer type.

2.2.2.2 Pressure Transmitters

Provide transmitters integral with the pressure transducer.

2.2.3 Current Transducers

Provide current transducers to monitor motor amperage, unless current switches are shown on design drawings or point tables.

2.2.4 Pneumatic to Electric Transducers

Pneumatic to electronic transducers shall convert a 0 to 20 psig signal to a proportional 4 to 20 mA or 0 to 10 VDC signal (operator scaleable). Supply voltage shall be 24 VDC. Accuracy and linearity shall be 1.0 percent or better.

2.2.5 Air Quality Sensors

Provide power supply for each sensor.

2.2.5.1 CO2 Sensors

Provide photo-acoustic type CO2 sensors with integral transducers and linear output. The devices shall read CO2 concentrations between 0 and 2000 ppm with full scale accuracy of at least plus or minus 100 ppm.

2.2.5.2 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor shall monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor shall automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

2.2.6 Input Switches

2.2.6.1 Timed Local Overrides

Provide buttons or switches to override the DDC occupancy schedule programming for each major building zone during unoccupied periods, and to return HVAC equipment to the occupied mode. This requirement is waived for zones clearly intended for 24 hour continuous operation.

2.2.7 Freeze Protection Thermostats

Provide special purpose thermostats with flexible capillary elements 20 feet minimum length for coil face areas up to 40 square feet. Provide longer elements for larger coils at 1-foot of element for every 4 square feet of coil face area, or provide additional thermostats. Provide switch contacts rated for the respective motor starter's control circuit voltage. Include auxiliary contacts for the switch's status condition. A freezing condition at any 18-inch increment along the sensing element's length shall activate the switch. The thermostat shall be equipped with a manual push-button reset switch so that when tripped, the thermostat requires manual resetting before the HVAC equipment can restart.

2.2.8 Air Flow Measurement Stations

Air flow measurement stations shall have an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be the RTD or thermistor type, traversing the ducted air in at least two directions. The air flow pressure drop across the station shall not exceed 0.08 inch water gage at a velocity of 2,000 fpm. The station shall be suitable for air flows up to 5,000 fpm, and a temperature range of 40 to 120 degrees F. The station's measurement accuracy over the range of 125 to 2,500 fpm shall be plus or minus 3 percent of the measured velocity. Station transmitters shall provide a linear, temperature-compensated 4 to 20 mA or 0 to 10 VDC output. The output shall be capable of being accurately converted to a corresponding air flow rate in cubic feet per minute. Transmitters shall be a 2-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the measurement.

2.2.9 Energy Metering

2.2.9.1 Electric Meters

Provide kilowatt-hour (kWh) meter(s) shown in accordance with NEMA/ANSI C12.10, suitable for the intended voltage, phases, and wye/delta configuration, with three current transformers and an output signal compatible with the DDC system. The meter shall have a box-mounted socket and an automatic circuit-closing bypass. Provide the meter with at least four pointer-type kWh registers, provisions for pulse initiation, and universal Class 2 indicating maximum kW demand register, sweep pointer indicating type, and a 15 minute interval. The meter accuracy shall be within plus or minus one percent of the actual kWh. Provide the correct multiplier on the meter face. Provide the current transformers in accordance with IEEE C57.13, with 600-volt insulation, and rated for metering with voltage, IL, momentary, and burden ratings coordinated with the ratings of corresponding meters. Provide butyl-molded donut or window type transformers mounted on a bracket to allow secondary cables to connect to the transformer bushings. Provide wiring identification of the current transformer secondary feeders to permit field measurements to be taken with hook-on ammeters.

2.2.9.2 Steam Meters

Steam meters shall be the vortex type, with pressure compensation, a minimum turndown ratio of 10 to 1, and an output signal compatible with the DDC system.

2.3 OUTPUT HARDWARE

2.3.1 Control Dampers

Provide factory manufactured galvanized or stainless steel dampers where indicated. Control dampers shall comply with SMACNA 1966 except as modified or supplemented by this specification. Published damper leakage rates and respective pressure drops shall have been verified by tests in compliance with AMCA 500-D requirements.

Provide damper assembly frames constructed of 1.62 mm (0.064 inch) minimum thickness galvanized or stainless steel channels with mitered and welded corners. Damper axles shall be 13 mm (0.5 inches) minimum diameter plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings.

Dampers shall be rated for not less than 10 m/s (2000 fpm) air velocity. The pressure drop through each damper when full-open shall not exceed 10

Pa water gage at 5 m/s (0.04 inches water gage at 1000 fpm) face velocity. Damper assemblies in ductwork subject to above 746 Pa (3-inch) water gauge static air pressure shall be constructed to meet SMACNA Seal Class "A" construction requirements.

Provide the damper operating linkages outside of the air stream, including crank arms, connecting rods, and other hardware that transmits motion from the damper actuators to the dampers, shall be adjustable. Additionally, operating linkages shall be designed and constructed to have a 2 to 1 safety factor when loaded with the maximum required damper operating force. Linkages shall be brass, bronze, galvanized steel, or stainless steel.

Provide access doors or panels in hard ceilings and walls for access to all concealed damper operators and damper locking setscrews.

For field-installed control dampers, a single damper section shall have blades no longer than 1220 mm (48 inches) and no higher than 1830 mm (72 inches). The maximum damper blade width shall be 305 mm (12 inches). Larger sized dampers shall be built using a combination of sections.

Frames shall be at least 50 mm (2 inches) wide. Flat blades shall have edges folded for rigidity. Blades shall be provided with compressible gasket seals along the full length of the blades to prevent air leakage when closed.

The damper frames shall be provided with jamb seals to minimize air leakage. Seals shall be suitable for an operating temperature range of minus 40 degrees C to 93 degrees C (minus 40 degrees F to 200 degrees F).

The leakage rate of each damper when full-closed shall be no more than 2 l/s per sq. meter (4 cfm per sq. foot) of damper face area at 996 Pa (1.0 inches) water gage static pressure.

2.3.2   Control Valves

2.3.2.1   Valve Assembly

Valve bodies shall be designed for 125 psig minimum working pressure or 150 percent of the operating pressure, whichever is greater. Valve stems shall be Type 316 stainless steel. Valve leakage ratings shall be 0.01 percent of rated Cv value. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall meet the requirements of ASME B16.5. Cast iron valve components shall meet the requirements of ASTM A126 Class B or C.

2.3.2.2   Butterfly Valves

Butterfly valves shall be the threaded lug type suitable for dead-end service and for modulation to the fully-closed position, with stainless steel shafts supported by bearings, non-corrosive discs geometrically interlocked with or bolted to the shaft (no pins), and EPDM seats suitable for temperatures from minus 29 degrees C to plus 121 degrees C (minus 20 degrees F to plus 250 degrees F). Valves shall have a means of manual operation independent of the actuator.

2.3.2.3   Two-Way Valves

Two-way modulating valves shall have an equal percentage characteristic.

2.3.2.4 Three-Way Valves

Three-way valves shall have an equal percentage characteristic.

2.3.2.5 Valves for Chilled Water, Condenser Water, and Glycol Fluid Service

a. Bodies for valves 40 mm (1-1/2 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 50 to 80 mm (2 inches to 3 inches) inclusive shall be of brass, bronze, or iron. Bodies for 50 mm (2 inch) valves shall have threaded connections. Bodies for valves from 65 to 80 mm (2-1/2 to 3 inches) shall have flanged connections.

b. Internal valve trim shall be brass or bronze, except that valve stems shall be stainless steel.

c. Unless indicated otherwise, provide modulating valves sized for (2 psi) minimum and (4 psi) maximum differential across the valve at the design flow rate.

d. Valves 100 mm (4 inches) and larger shall be butterfly valves, unless indicated otherwise.

2.3.2.6 Valves for Hot Water Service

Valves for hot water service below 121 degrees C (250 Degrees F):

a. Bodies for valves 40 mm (1-1/2 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 50 to 80 mm (2 inches to 3 inches) inclusive shall be of brass, bronze, or iron. Bodies for 50 mm (2 inch) valves shall have threaded connections. Bodies for valves from 65 to 80 mm (2-1/2 to 3 inches) shall have flanged connections.

b. Internal trim (including seats, seat rings, modulation plugs, valve stems, and springs) of valves controlling water above 99 degrees C (210 degrees F) shall be Type 316 stainless steel.

c. Internal trim for valves controlling water 99 degrees C (210 degrees F) or less shall be brass or bronze. Valve stems shall be Type 316 stainless steel.

d. Non-metallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of 121 degrees C or 28 degrees C (250 degrees F or 50 degrees F) above the system design temperature, whichever is higher.

e. Unless indicated otherwise, provide modulating valves sized for (2 psi) minimum and (4 psi) maximum differential across the valve at the design flow rate.

f. Valves 100 mm (4 inches) and larger shall be butterfly valves, unless indicated otherwise.

2.3.2.7 Valves for High Temperature Hot Water Service

Valves for hot water service 121 degrees C (250 Degrees F) above:

a. Valve bodies shall conform to ASME B16.34 Class 300. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves 25 mm (1 inch) and larger. Valves smaller than 25 mm (1 inch) shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE).

b. Internal valve trim shall be Type 316 stainless steel.

c. Unless indicated otherwise, provide modulating valves sized for (2 psi) minimum and (4 psi) maximum differential across the valve at the design flow rate.

2.3.2.8 Valves for Steam Service

The entire body for valves 40 mm (1-1/2 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 50 to 80 mm (2 to 3 inches) inclusive shall be of brass, bronze, or carbon steel. Bodies for valves 100 mm (4 inches) and larger shall be carbon steel. Bodies for 50 mm (2 inch) valves shall have threaded connections. Bodies for valves 65 mm (2-1/2 inches) and larger shall have flanged connections. Steam valves shall be sized for 103 kPa (gage) (15 psig(inlet steam pressure with a maximum 90 kPa (13 psi) differential through the valve at rated flow, except where indicated otherwise. Internal valve trim shall be Type 316 stainless steel.

2.3.3 Actuators

Provide direct-drive electric actuators for all control applications, except where indicated otherwise.

2.3.3.1 Electric Actuators

Each actuator shall deliver the torque required for continuous uniform motion and shall have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators shall function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds. Provide two-position actuators of single direction, spring return, or reversing type. Provide modulating actuators capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators shall be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual adjustments, as applicable. Thermal type actuators may only be used on terminal fan coil units, terminal VAV units, convectors, and unit heaters. Spring return actuators shall be provided on all control dampers and all control valves except terminal fan coil units, terminal VAV units, convectors, and unit heaters; unless indicated otherwise. Each actuator shall have distinct markings indicating the full-open and full-closed position, and the points in-between.

2.3.3.2 Pneumatic Actuators

Provide piston or diaphragm type actuators

2.3.4 Output Signal Conversion

2.3.4.1 Electronic-to-Pneumatic Transducers

Electronic to pneumatic transducers shall convert a 4 to 20 mA or 0 to 10 VDC digital controller output signal to a proportional 0 to 20 psig pressure signal (operator scaleable). Accuracy and linearity shall be 1.0 percent or better. Transducers shall have feedback circuit that converts the pneumatic signal to a proportional 4 to 20 mA or 0 to 10 VDC signal.

2.3.5 Output Switches

2.3.5.1 Control Relays

Field installed and DDC panel relays shall be double pole, double throw, UL listed, with contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light shall be lit when the coil is energized and off when coil is not energized. Relays shall be the socket type, plug into a fixed base, and replaceable without tools or removing wiring. Encapsulated "PAM" type relays may be used for terminal control applications.

2.4 ELECTRICAL POWER AND DISTRIBUTION

2.4.1 Transformers

Transformers shall conform to UL 506. For control power other than terminal level equipment, provide a fuse or circuit breaker on the secondary side of each transformer.

2.4.2 Surge and Transient Protection

Provide each digital controller with surge and transient power protection. Surge and transient protection shall consist of the following devices, installed externally to the controllers.

2.4.2.1 Power Line Surge Protection

Provide surge suppressors on the incoming power at each controller or grouped terminal controllers. Surge suppressors shall be rated in accordance with UL 1449, have a fault indicating light, and conform to the following:

a. The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.

b. The device shall react within 5 nanoseconds and automatically reset.

c. The voltage protection threshold, line to neutral, shall be no more than 211 volts.

d. The device shall have an independent secondary stage equal to or greater than the primary stage joule rating.

e. The primary suppression system components shall be pure silicon avalanche diodes.

f. The secondary suppression system components shall be silicon avalanche diodes or metal oxide varistors.

g. The device shall have an indication light to indicate the protection components are functioning.

h. All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.

i. The device shall have an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz.

j. The device shall comply with IEEE C62.41.1 and IEEE C62.41.2, Class "B" requirements and be tested according to IEEE C62.45.

k. The device shall be capable of operating between minus 20 degrees F and plus 122 degrees F.

2.4.2.2 Telephone and Communication Line Surge Protection

Provide surge and transient protection for DDC controllers and DDC network related devices connected to phone and network communication lines, in accordance with the following:

a. The device shall provide continuous, non-interrupting protection, and shall automatically reset after safely eliminating transient surges.

b. The protection shall react within 5 nanoseconds using only solid-state silicon avalanche technology.

c. The device shall be installed at the distance recommended by its manufacturer.

2.4.2.3 Controller Input/Output Protection

Provide controller inputs and outputs with surge protection via optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

2.4.3 Wiring

Provide complete electrical wiring for the DDC System, including wiring to transformer primaries. Unless indicated otherwise, provide all normally visible or otherwise exposed wiring in conduit. Where conduit is required, control circuit wiring shall not run in the same conduit as power wiring over 100 volts. Circuits operating at more than 100 volts shall be in accordance with Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM. Run all circuits over 100 volts in conduit, metallic tubing, covered metal raceways, or armored cable. Use plenum-rated cable for circuits under 100 volts in enclosed spaces. Examples of these spaces include HVAC plenums, within walls, above suspended ceilings, in attics, and within ductwork.

2.4.3.1 Power Wiring

The following requirements are for field-installed wiring:

a. Wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.

b. Wiring for 120 V circuits shall be insulated copper 14 AWG minimum and rated for 600 VAC service.

2.4.3.2 Analog Signal Wiring

Field-installed analog signal wiring shall be 18 AWG single or multiple twisted pair. Each cable shall be 100 percent shielded and have a 20 AWG drain wire. Each wire shall have insulation rated for 300 VAC service. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape.

2.5 FIRE PROTECTION DEVICES

2.5.1 Duct Smoke Detectors

Provide duct smoke detectors in HVAC ducts in accordance with NFPA 72 and NFPA 90A, except as indicated otherwise. Provide UL listed or FM approved detectors, designed specifically for duct installation.

Furnish detectors under Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE and install under this section. Connect new detectors to the building fire alarm panel.

2.6 INDICATORS

2.6.1 Thermometers

Provide bi-metal type thermometers at locations shown. Thermometers shall have either 9 inch long scales or 3.5 inch diameter dials, with insertion, immersion, or averaging elements. Provide matching thermowells for pipe-mounted installations. Select scale ranges suitable for the intended service, with the normal operating temperature near the scale's midpoint. The thermometer's accuracy shall be plus or minus 2 percent of the scale range.

2.6.2 Pressure Gauges for Piping Systems

Provide pipe-mounted pressure gauges at the locations shown. Gauges shall conform to ASME B40.100 and have a 4-inch diameter dial and shutoff cock. Provide gauges in steam piping with a pressure snubber pigtail fitting. Select scale ranges suitable for the intended service, with the normal operating pressure near the scale's midpoint. The gauge's accuracy shall be plus or minus 2 percent of the scale range.

2.6.3 Pressure Gauges for Pneumatic Controls

Provide a pressure gauge at each pneumatic control input and output. Gauges shall have a 2-inch diameter face and a 0 to 30 psi scale with 1 psi graduations.

2.7 PNEUMATIC POWER SUPPLY AND TUBING

2.7.1 Air Compressors

Air compressors for pneumatic control systems shall be the tank-mounted, electric motor driven, air cooled, reciprocating type with integral duplex motors and compressors or single motor and compressor, tank, controller, alternator switch, pressure switch, belt guard(s), pressure relief valve, and automatic moisture drain valve. Compressor piston speeds shall not exceed 450 fpm. Provide compressors with a dry-type combination intake air filter and silencer with baked enamel steel housing. The filter shall be 99 percent efficient at 10 microns. The pressure switch shall start the compressor(s) at 70 psig and stop the compressor(s) at 90 psig. The relief valve shall be set for 10 to 25 psig above the control switch cut-off pressure. Provide compressor capacity suitable for not more than a 50 percent run time, at full system control load. Compressors shall have a maintaining type starter, and shall automatically restart after a power outage. Motors 0.5 hp and larger shall be three-phase.

2.7.1.1 Compressed Air Tank

Provide a steel tank constructed and labeled in agreement with ASME BPVC for 125 psig maximum working pressure. Size the tank for the compressor run time specified above. Provide drain valve and piping routing the drainage to a floor sink or other safe and visible drainage location.

2.7.2 Refrigerated Air Dryers

Provide each air compressor tank with a refrigerant air dryer sized for continuous operation, and capable of reducing the compressed air dew point temperature, at 20 psig output pressure, to 30 degrees F, at an average tank pressure of 80 psig and an ambient air temperature between 55 and 95 degrees F. Provide each dryer with an automatic condensate drain trap with manual override feature. Provide the dryer suction line with a refrigerant pressure gauge. Locate each dryer in the air piping between the tank and the pressure-reducing station.

2.7.3 Compressed Air Discharge Filters

Provide air compressors with a dry type discharge filter, 99 percent efficient at removing oil and solid particles at 0.03 microns, with baked enamel steel housing and manual drain valve. Provide visual indicator to show when the filter element should be changed.

2.7.4 Air Pressure-Reducing Stations

Provide air compressors with a pressure-reducing valve (PRV) with a field adjustable range of 0 to 50 psig discharge pressure, at an inlet pressure of 70 to 90 psig. Provide a factory-set pressure relief valve downstream of the PRV to relieve over-pressure. Provide a pressure gage upstream of the PRV with range of 0 to 100 psig and downstream of the PRV with range of 0 to 30 psig. For two-pressure control systems, provide an additional PRV and downstream pressure gage.

2.7.5 In-line Filters

Provide a disposable type in-line filter in the incoming pneumatic main at each pneumatic control panel. The filter shall be capable of eliminating 99.99 percent of all liquid or solid contaminants 0.1 micron or larger. Provide the filter with fittings that allow easy removal/replacement.

2.7.6 Pneumatic Tubing

2.7.6.1 Copper Tubing

Provide ASTM B75/B75M or ASTM B88M (ASTM B88) rated tubing. Tubing 0.64 mm (0.375 inch) outside diameter and larger shall have minimum wall thickness equal to ASTM B88M (ASTM B88), Type M. Tubing less than 10 mm (0.375 inch) outside diameter shall have minimum wall thickness of 0.64 mm

(0.025 inch). Exposed tubing and tubing for working pressures greater than 30 psig shall be hard copper. Fittings shall be ASME B16.18 or ASME B16.22 solder type using ASTM B32 95-5 tin-antimony solder, or ASME B16.26 compression type.

2.7.6.2 Polyethylene Tubing

Polyethylene tubing may only be used in systems with working pressure of 30 psig or less. Provide flame-resistant, multiple polyethylene tubing in flame-resistant protective sheath with mylar barrier, or unsheathed polyethylene tubing in rigid metal, intermediate metal, or electrical metallic tubing conduit for areas where tubing is exposed. Single, unsheathed, flame-resistant polyethylene tubing may be used where concealed in walls or above ceilings and within control panels. Do not provide polyethylene tubing for systems indicated as critical and smoke removal systems. Provide compression or brass barbed push-on type fittings. Extruded seamless polyethylene tubing shall conform to the following:

a. Minimum Burst Pressure Requirements: 690 kPA (100 psig) at 24 degrees C (75 degrees F) to 172 kPa (25 psig) at 66 degrees C (150 degrees F).

b. Stress Crack Resistance: ASTM D1693, 200 hours minimum.

c. Tensile Strength (Minimum): ASTM D638, 7583 kPa (1100 psi).

d. Flow Rate (Average): ASTM D1238, 0.30 decigram per minute.

e. Density (Average): ASTM D792, 920 kg/m3 (57.5 pounds per cubic feet).

f. Burn rate: ASTM D635

2.8 VARIABLE FREQUENCY (MOTOR) DRIVES

Provide variable frequency drives (VFDs) as indicated. VFDs shall convert 240 or 460 volt (plus or minus 10 percent), three phase, 60 hertz (plus or minus 2Hz), utility grade power to adjustable voltage/frequency, three phase, AC power for stepless motor control from 5 percent to 105 percent of base speed. VFDs shall be UL listed as delivered to the end user. The VFD shall meet the requirements specified in the most current National Electrical Code. Each VFD shall also meet the following:

a. The VFD shall use sine coded Pulse Width Modulation (PWM) technology. PWM calculations shall be performed by the VFD microprocessor.

b. The VFD shall be capable of automatic control by a remote 4-20 mA 0 to 10 VDC signal, by network command, or manually by the VFD control panel.

2.8.1 VFD Quality Assurance

VFDs shall be the manufacturer's current standard production unit with at least 10 identical units successfully operating in the field.

2.8.2 VFD Service Support

a. Warranty: Provide the VFDs with a minimum 24-month full parts and labor warranty. The warranty shall start when the contract's HVAC system is accepted by the Government. Include warranty documentation, dates, and contact information with the VFD on-site service manuals.

b. VFD Service Manuals: Provide the VFDs with all necessary installation, operation, maintenance, troubleshooting, service, and repair manuals in English including related factory technical bulletins. Provide the documents factory bound, in sturdy 3-ring binders, or hard bound covers. Provide a title sheet on the outside of each binder indicating the project title, project location, installing contractor, contract number, and the VFD manufacturer, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. The documentation provided shall be specifically applicable to this project, shall be annotated to reflect the actual project conditions, and shall provide a complete and concise depiction of the installed work. Provide a storage cabinet on or near the VFD large enough to hold all of the documentation. Have the cabinet's proposed installation site approved in advance by the Contracting Officer. Prominently label the cabinet "VFD OPERATION AND MAINTENANCE MANUALS." Clearly label each manual with the wording "MECHANICAL ROOM COPY - DO NOT REMOVE".

c. Technical Support: Provide the VFDs with manufacturer's technical telephone support in English, readily available during normal working hours, and free of charge for the life of the equipment.

d. Initial Start-Up: Provide the VFDs with factory-trained personnel for the on-site start-up of the HVAC equipment and associated VFD. The personnel shall be competent in the complete start-up, operation, and repair of the particular model VFD installed. The factory start-up representative shall perform the factory's complete recommended start-up procedures and check-out tests on the VFD. Include a copy of the start-up test documentation with the VFD on-site service manuals.

e. Provide the VFDs with on-site/hands-on training for the user and maintenance personnel. Provide a capable and qualified instructor with minimum two years field experience with the operation and maintenance of similar VFDs. The training shall occur during normal working hours and last not less than 2 hours. Coordinate the training time with the Contracting Officer and the end user. The VFD service manuals shall be used during the training. The contractor shall ensure the manuals are on-site before the start of training. The training shall cover all operational aspects of the VFD.

2.8.3 VFD Features

VFDs shall have the following features:

a. A local operator control keypad capable of:

(1) Remote/Local operator selection with password access.

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

b. Digital display capable of indicating:

(1) VFD status.

(2) Frequency.

(3) Motor RPM.

(4) Phase current.

(5) Fault diagnostics in descriptive text.

(6) All programmed parameters.

c. Standard PI loop controller with input terminal for controlled variable and parameter settings.

d. User interface terminals for remote control of VFD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.

e. An isolated form C SPDT auxiliary relay which energizes on a run command.

f. A metal NEMA 1 enclosure for indoors, NEMA 4 with heater for outdoors.

g. An adjustable carrier frequency with 16 KHz minimum upper limit.

h. A built in or external line reactor with 3 percent minimum impedance to protect the VFDs DC buss capacitors and rectifier section diodes.

2.8.4 Programmable Parameters

VFDs shall include the following operator programmable parameters:

a. Upper and lower limit frequency.

b. Acceleration and Deceleration rate.

c. Variable torque volts per Hertz curve.

d. Starting voltage level.

e. Starting frequency level.

f. Display speed scaling.

g. Enable/disable auto-restart feature.

h. Enable/disable soft stall feature.

i. Motor overload level.

j. Motor stall level.

k. Jump frequency and hysteresis band.

l. PWM carrier frequency.

2.8.5 Protective Features

VFDs shall have the following protective features:

a. An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.

b. An electronic adjustable soft stall feature, allowing the VFD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload condition exists at the requested frequency. The VFD will automatically return to the requested frequency when load conditions permit.

c. A separate electronic stall at 110 percent VFD rated current, and a separate hardware trip at 190 percent current.

d. Ground fault protection that protects the output cables and motor from grounds during both starting and continuous running conditions.

e. The ability to restart after the following faults:

   (1) Overcurrent (drive or motor).

   (2) Power outage.

   (3) Phase loss.

   (4) Over voltage/Under voltage.

f. The ability shut down if inadvertently started into a rotating load without damaging the VFD or the motor.

g. The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.

h. The ability to sustain 110 percent rated current for 60 seconds

i. The ability to shutdown safely or protect against and record the following fault conditions:

   (1) Over current (and an indication if the over current was during acceleration, deceleration, or running).

   (2) Over current internal to the drive.

   (3) Motor overload at start-up.

   (4) Over voltage from utility power.

   (5) Motor running overload.

   (6) Over voltage during deceleration.

   (7) VFD over heat.

   (8) Load end ground fault.

(9) Abnormal parameters or data in VFD EEPROM.

2.8.6 Minimum Operating Conditions

VFDs shall be designed and constructed to operate within the following service conditions:

a. Ambient Temperature Range, 0 to 120 degrees F.

b. Non-condensing relative humidity to 90 percent.

2.8.7 Additional Features

Provide VFDs with the following additional features:

a. BACnet communication interface port

b. RFI/EMI filters

c. Manual bypass circuit and switch integral external to the drive to allow drive bypass and operation at 100 percent speed. Motor overload and short circuit protective features shall remain in use during the bypass mode.

d. One spare VFD of each model provided, fully programmed and ready for back-up operation when connected.

PART 3 EXECUTION

3.1 INSTALLATION

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1 BACnet Naming and Addressing

Coordinate with the BAS Owner and provide unique naming and addressing for BACnet networks and devices.

a. MAC Address

Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For ARCNET or MS/TP, assign from 00 to 64.

b. Network Numbering

Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.

c. Device Object Identifier Property Number

Assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface. BACnet allows up to 4,194,302 possible unique devices per internetwork.

d. Device Object Name Property Text

The Device Object Name property field shall support 32 minimum printable characters. Assign unique Device "Object_Name" property names with plain-English descriptive names for each device For example, the Device Object Name that for the device controlling the chiller plant at Building 3408 would be:

Device Object_Name = CW System B3408

A Device Object Name for a VAV box controller might be:

Device Object_Name = VAV BOX25

e. Object Name Property Text (Other than Device Objects)

The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application. Examples include "Zone 1 Temperature" and "Fan Start/Stop".

f. Object Identifier Property Number (Other than Device Objects)

Assign Object Identifier property numbers according to design drawings or tables if provided. If not provided, Object Identifier property numbers may be assigned at the Contractor's discretion but must be approved by the Government. In this case they must be documented and unique for like object types within the device.

3.1.2 Minimum BACnet Object Requirements

a. Use of Standard BACnet Objects

For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service:
all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.

b. BACnet Object Description Property

The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.

c. Analog Input, Output, and Value Objects

Support and provide Description and/or Device_Type text strings matching signal type and engineering units shown on the points list.

d. Binary Input, Output, and Value Objects

Support and provide Inactive_Text and Active_Text property descriptions matching conditions shown on the points list.

e. Calendar Object

For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. All operators may view Calendar Objects; authorized operators may make modifications from a workstation. Enable the writeable Date List property and support all calendar entry data types.

f. Schedule Object

Use Schedule Objects for all building system scheduling. All operators may view schedule entries; authorized operators may modify schedules from a workstation.

g. Loop Object or Equal

Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint, Proportional Constant, Integral Constant, and Derivative Constant using BACnet read/write services.

3.1.3 Minimum BACnet Service Requirements

a. Command Priorities

Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below. If the sequence of operation requires a different priority, obtain approval from the Contracting Officer.

Priority Level	Application
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)

Priority Level	Application
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)
16	(User Defined)

b. Alarming

(1) Alarm Priorities - Coordinate alarm and event notification with the BAS Owner.

(2) Notification Class - Enable writeable Priority, Ack Required, and Recipient List properties of Notification Class objects.

(3) Event Notification Message Texts - Use condition specific narrative text and numerical references for alarm and event notification.

c. Updating Displayed Property Values

Allow workstations to display property values at discrete polled intervals, or based on receipt of confirmed and unconfirmed Change of Value notifications. The COV increment shall be adjustable by an operator using BACnet services, and polled intervals shall be adjustable at the operator workstation.

3.1.4 Local Area Networks

Obtain Government approval before connecting new networks with existing networks. Network numbers and device instance numbers shall remain unique when joining networks. Do not change existing network addressing without Government approval. See also "BACnet Naming and Addressing".

3.1.5 BACnet Routers, Bridges, and Switches

Provide the quantity of BACnet routers, bridges, and switches necessary for communications shown on the BACnet Communication Architecture schematic. Provide BACnet routers with BACnet Broadcast Message Device (BBMD) capability on each BACnet internetwork communicating across an IP network. Configure each BACnet device and bridge, router, or switch to communicate on its network segment.

3.1.6 Wiring Criteria

a. Run circuits operating at more than 100 volts in rigid or flexible conduit, metallic tubing, covered metal raceways, or armored cable.

b. Do not run binary control circuit wiring in the same conduit as power wiring over 100 volts. Where analog signal wiring requires conduit, do not run in the same conduit with AC power circuits or control circuits operating at more than 100 volts.

c. Provide circuit and wiring protection required by NFPA 70.

d. Run all wiring located inside mechanical rooms in conduit.

e. Do not bury aluminum-sheathed cable or aluminum conduit in concrete.

f. Input/output identification: Permanently label each field-installed wire, cable, and pneumatic tube at each end with descriptive text using a commercial wire marking system that fully encircles the wire, cable, or tube. Locate the markers within 2 inches of each termination. Match the names and I/O number to the project's point list. Similarly label all power wiring serving control devices, including the word "power" in the label. Number each pneumatic tube every six feet. Label all terminal blocks with alpha/numeric labels. All wiring and the wiring methods shall be in accordance with UL 508A.

g. For controller power, provide new 120 VAC circuits, with ground. Provide each circuit with a dedicated breaker, and run wiring in its own conduit, separate from any control wiring. Connect the controller's ground wire to the electrical panel ground; conduit grounds are not acceptable.

h. Surge Protection: Install surge protection according to manufacturer's instructions. Multiple controllers fed from a common power supply may be protected by a common surge protector, properly sized for the total connected devices.

i. Grounding: Ground controllers and cabinets to a good earth ground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Conduit grounding is not acceptable; all grounding shall have a direct path to the building earth ground. Ground sensor drain wire shields at the controller end.

j. The Contractor shall be responsible for correcting all associated ground loop problems.

k. Run wiring in panel enclosures in covered wire track.

3.1.7 Accessibility

Install all equipment so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install digital controllers, data ports, and concealed actuators, valves, dampers, and like equipment in locations freely accessible through access doors.

3.1.8 Digital Controllers

a. Install as stand alone control devices (see definitions).

b. Locate control cabinets at the locations shown on the drawings. If not shown on the drawings, install in the most accessible space, close to the controlled equipment.

3.1.9 Hand-Off-Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.10 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate sensors according to manufacturer's instructions. Do not use sensors designed for one application in a different application.

3.1.10.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of the sensor 5 feet above the finished floor unless otherwise indicated on drawings.

3.1.10.2 Duct Temperature Sensors

a. Probe Type: Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. Seal the duct insulation penetration vapor tight.

b. Averaging Type (and coil freeze protection thermostats): Weave the capillary tube sensing element in a serpentine fashion perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports. Prevent contact between the capillary and the duct or air handler internals. Provide a duct access door at the sensor location. The access door shall be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors shall be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.10.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermal conductivity material within the well to fully coat the inserted sensor.

3.1.10.4 Outside Air Temperature Sensors

Provide outside air temperature sensors in weatherproof enclosures on the north side of the building, away from exhaust hoods and other areas that may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.11 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous and accumulated energy usage.

3.1.12 Damper Actuators

Where possible, mount actuators outside the air stream in accessible areas.

3.1.13 Thermometers and Gages

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.14 Pressure Sensors

Locate pressure sensors as indicated.

3.1.15 Pneumatic Tubing

Run tubing concealed in finished areas, run tubing exposed in unfinished areas like mechanical rooms. For tubing enclosed in concrete, provide rigid metal conduit. Run tubing parallel and perpendicular to building walls. Use 5 foot maximum spacing between tubing supports. With the compressor turned off, test each tubing system pneumatically at 1.5 times the working pressure and prove it air tight, locating and correcting leaks as applicable. Caulking joints is not permitted. Do not run tubing and electrical power conductors in the same conduit.

3.1.16 Component Identification Labeling

Using an electronic hand-held label maker with white tape and bold black block lettering, provide an identification label on the exterior of each new control panel, control device, actuator, and sensor. Also provide labels on the exterior of each new control actuator indicating the (full) open and (full) closed positions. For labels located outdoors, use exterior grade label tape, and provide labels on both the inside and outside of the panel door or device cover. Acceptable alternatives are white plastic labels with engraved bold black block lettering permanently attached to the control panel, control device, actuator, and sensor. Have the labels and wording approved by the BAS Owner prior to installation.

3.1.17 Network and Telephone Communication Lines

When telephone lines or network connections by the Government are required, provide the Contracting Officer at least 60 days advance notice of need.

3.2 TEST AND BALANCE SUPPORT

The controls contractor shall coordinate with and provide on-site support to the test and balance (TAB) personnel specified under Section 23 05 93 TESTING, ADJUSTING AND BALANCING. This support shall include:

a. On-site operation and manipulation of control systems during the testing and balancing.

b. Control setpoint adjustments for balancing all relevant mechanical systems, including VAV boxes.

c. Tuning control loops with setpoints and adjustments determined by TAB personnel.

3.3 CONTROLS SYSTEM OPERATORS MANUALS

Provide one hard copy & one digital copy (.pdf - text searchable) of a Controls System Operators Manual. The manual shall be specific to the project, written to actual project conditions, and provide a complete and concise depiction of the installed work. Provide information in detail to clearly explain all operation requirements for the control system.

Provide with each manual: CDs of the project's control system drawings, control programs, data bases, graphics, and all items listed below. Include gateway back-up data and configuration tools where applicable. Provide CDs in jewel case with printed and dated project-specific labels on both the CD and the case. For text and drawings, use Adobe Acrobat or MS Office file types. When approved by the Government, AutoCAD and Visio files are allowed. Give files descriptive English names and organize in folders.

Provide printed manuals in sturdy 3-ring binders with a title sheet on the outside of each binder indicating the project title, project location, contract number, and the controls contractor name, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. Manuals shall include the following:

a. A copy of the as-built control system (shop) drawings set, with all items specified under the paragraph "Submittals." Indicate all field changes and modifications.

b. A copy of the project's mechanical design drawings, including any official modifications and revisions.

c. A copy of the project's approved Product Data submittals provided under the paragraph "Submittals."

d. A copy of the project's approved Performance Verification Testing Plan and Report.

e. A copy of the project's approved final TAB Report.

f. Printouts of all control system programs, including controller setup pages if used. Include plain-English narratives of application programs, flowcharts, and source code.

g. Printouts of all physical input and output object properties, including tuning values, alarm limits, calibration factors, and set points.

h. A table entitled "AC Power Table" listing the electrical power source for each controller. Include the building electrical panel number, panel location, and circuit breaker number.

i. The DDC manufacturer's hardware and software manuals in both print and CD format with printed project-specific labels. Include installation and technical manuals for all controller hardware, operator manuals for all controllers, programming manuals for all controllers, operator manuals for all workstation software, installation and technical manuals for the workstation and notebook, and programming manuals for the workstation and notebook software.

j. A list of qualified control system service organizations for the work provided under this contract. Include their addresses and telephone numbers.

k. A written statement entitled "Technical Support" stating the control system manufacturer or authorized representative will provide toll-free telephone technical support at no additional cost to the Government for a minimum of two years from project acceptance, will be furnished by experienced service technicians, and will be available during normal weekday working hours. Include the toll-free technical support telephone number.

l. A written statement entitled "Software Upgrades" stating software and firmware patches and updates will be provided upon request at no additional cost to the Government for a minimum of two years from contract acceptance. Include a table of all DDC system software and firmware provided under this contract, listing the original release dates, version numbers, part numbers, and serial numbers.

3.4 PERFORMANCE VERIFICATION TESTING (PVT)

3.4.1 General

The PVT shall demonstrate compliance of the control system work with the contract requirements. The PVT shall be performed by the Contractor and witnessed and approved by the Government. If the project is phased, provide separate testing for each phase. A Pre-PVT meeting to review the Pre-PVT Checklist is required to coordinate all aspects of the PVT and shall include the Contractor's QA representative, the Contractor's PVT administrator, the Contracting Officer's representative, and the BAS Owner.

3.4.2 Performance Verification Testing Plan

Submit a detailed PVT Plan of the proposed testing for Government approval. Develop the PVT Plan specifically for the control system in this contract. The PVT Plan shall be an clear list of test items arranged in a logical sequence. Include the intended test procedure, the expected response, and the pass/fail criteria for every component tested.

The plan shall clearly describe how each item is tested, indicate where assisting personnel are required (like the mechanical contractor), and include what procedures are used to simulate conditions. Include a separate column for each checked item and extra space for comments. Where sequences of operations are checked, insert each corresponding routine from the project’s sequence of operation. For each test area, include signature and date lines for the Contractor's PVT administrator, the Contractor's QA representative, the Contracting Officer's representative, and the BAS Owner to acknowledge successful completion. The BAS Owner can provide sample PVT forms and procedures upon request.

3.4.3 PVT Sample Size

Test all central plant equipment and primary air handling unit controllers unless otherwise directed. Twenty percent sample testing is allowed for identical controllers typical of terminal control like VAV boxes and fan coil units. The Government may require testing of like controllers beyond a statistical sample if sample controllers require retesting or do not have consistent results.

The Government may witness all testing, or random samples of PVT items. When only random samples are witnessed, the Government may choose which ones.

3.4.4 Pre-Performance Verification Testing Checklist

Submit the following as a list with items checked off once verified. Provide a detailed explanation for any items that are not completed or verified.

a. Verify all required mechanical installation work is successfully completed, and all HVAC equipment is working correctly (or will be by the time the PVT is conducted).

b. Verify HVAC motors operate below full-load amperage ratings.

c. Verify all required control system components, wiring, and accessories are installed.

d. Verify the installed control system architecture matches approved drawings.

e. Verify all control circuits operate at the proper voltage and are free from grounds or faults.

f. Verify all required surge protection is installed.

g. Verify the A/C Power Table specified in "CONTROLS SYSTEM OPERATORS MANUALS" is accurate.

h. Verify all DDC network communications function properly, including uploading and downloading programming changes.

i. Using the BACnet protocol analyzer (if provided or required in this specification), verify communications are error free.

j. Verify each digital controller’s programming is backed up.

k. Verify all wiring, components, and panels are properly labeled.

l. Verify all required points are programmed into devices.

m. Verify all TAB work affecting controls is complete.

n. Verify all valve and actuator zero and span adjustments are set properly.

o. Verify all sensor readings are accurate and calibrated.

p. Verify each control valve and actuator goes to normal position upon loss of power.

q. Verify all control loops are tuned for smooth and stable operation. View trend data where applicable.

r. Verify each controller works properly in stand-alone mode.

s. Verify all safety controls and devices function properly, including freeze protection and interfaces with building fire alarm systems.

t. Verify all electrical interlocks work properly.

u. Verify all workstations, notebooks and maintenance personnel interface tools are delivered, all system and database software is installed, and graphic pages are created for each workstation and notebook.

v. Verify the as-built (shop) control drawings are completed.

3.4.5 Conducting Performance Verification Testing

a. Conduct Government-witnessed PVT after approval of the PVT Plan and the completed Pre-PVT Checklist. Notify the Contracting Officer of the planned PVT at least 15 days prior to testing. Provide an estimated time table required to perform the testing. Furnish personnel, equipment, instrumentation, and supplies necessary to perform all aspects of the PVT. Ensure that testing personnel are regularly employed in the testing and calibration of DDC systems. Using the project's as-built control system (shop) drawings, the project's mechanical design drawings, the approved Pre-PVT Checklist, and the approved PVT Plan, conduct the PVT.

b. During testing, identify any items that do not meet the contract requirements and if time permits, conduct immediate repairs and re-test. Otherwise, deficiencies shall be investigated, corrected, and re-tested later. Document each deficiency and corrective action taken.

c. If re-testing is required, follow the procedures for the initial PVT. The Government may require re-testing of any control system components affected by the original failed test.

3.4.6 Controller Capability and Labeling

Test the following for each controller:

a. Memory: Demonstrate that programmed data, parameters, and trend/ alarm history collected during normal operation is not lost during power failure.

b. Direct Connect Interface: Demonstrate the ability to connect directly to each type of digital controller with a portable electronic device like a notebook computer or PDA. Show that maintenance personnel interface tools perform as specified in the manufacturer's technical literature.

c. Stand Alone Ability: Demonstrate controllers provide stable and reliable stand-alone operation using default values or other method for values normally read over the network.

d. Wiring and AC Power: Demonstrate the ability to disconnect any controller safely from its power source using the AC Power Table. Demonstrate the ability to match wiring labels easily with the control drawings. Demonstrate the ability to locate a controller's location using the BACnet Communication Architecture Schematic and floor plans.

e. Nameplates and Tags: Show the nameplates and tags are accurate and permanently attached to control panel doors, devices, sensors, and actuators.

3.4.7 Workstation and Software Operation

For every user workstation or notebook provided:

a. Show points lists agree with naming conventions.

b. Show that graphics are complete.

c. Show the UPS operates as specified.

3.4.8 BACnet Communications and Interoperability Areas

Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. If available or required in this specification, use a BACnet protocol analyzer to assist with identifying devices, viewing network traffic, and verifying interoperability. These requirements must be met even if there is only one manufacturer of equipment installed. Testing includes the following:

a. Data Presentation: On each BACnet Operator Workstation, demonstrate graphic display capabilities.

b. Reading of Any Property: Demonstrate the ability to read and display any used readable object property of any device on the network.

c. Setpoint and Parameter Modifications: Show the ability to modify all setpoints and tuning parameters in the sequence of control or listed on project schedules. Modifications are made with BACnet messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.

d. Peer-to-Peer Data Exchange: Show all BACnet devices are installed and configured to perform BACnet read/write services directly (without the need for operator or workstation intervention), to implement the project sequence of operation, and to share global data.

e. Alarm and Event Management: Show that alarms/events are installed and prioritized according to the BAS Owner. Demonstrate time delays and other logic is set up to avoid nuisance tripping, e.g., no status alarms during unoccupied times or high supply air during cold morning start-up. Show that operators with sufficient privilege can read and write alarm/event parameters for all standard BACnet event types. Show that operators with sufficient privilege can change routing (BACnet notification classes) for each alarm/event including the destination, priority, day of week, time of day, and the type of transition involved (TO-OFF NORMAL, TO-NORMAL, etc.).

f. Schedule Lists: Show that schedules are configured for start/stop, mode change, occupant overrides, and night setback as defined in the sequence of operations.

g. Schedule Display and Modification: Show the ability to display any schedule with start and stop times for the calendar year. Show that all calendar entries and schedules are modifiable from any connected workstation by an operator with sufficient privilege.

h. Archival Storage of Data: Show that data archiving is handled by the operator workstation/server, and local trend archiving and display is accomplished with BACnet Trend Log objects.

i. Modification of Trend Log Object Parameters: Show that an operator with sufficient privilege can change the logged data points, sampling rate, and trend duration.

j. Device and Network Management: Show the following capabilities:

(1) Display of Device Status Information

(2) Display of BACnet Object Information

(3) Silencing Devices that are Transmitting Erroneous Data

(4) Time Synchronization

(5) Remote Device Reinitialization

(6) Backup and Restore Device Programming and Master Database(s)

(7) Configuration Management of Half-Routers, Routers and BBMDs

3.4.9 Execution of Sequence of Operation

Demonstrate that the HVAC system operates properly through the complete sequence of operation. Use read/write property services to globally read and modify parameters over the internetwork.

3.4.10 Control Loop Stability and Accuracy

For all control loops tested, give the Government trend graphs of the control variable over time, demonstrating that the control loop responds to a 20 percent sudden change of the control variable set point without excessive overshoot and undershoot. If the process does not allow a 20 percent set point change, use the largest change possible. Show that once the new set point is reached, it is stable and maintained. Control loop trend data shall be in real-time with the time between data points 30 seconds or less.

3.4.11 Performance Verification Testing Report

Upon successful completion of the PVT, submit a PVT Report to the Government and prior to the Government taking use and possession of the facility. Do not submit the report until all problems are corrected and successfully re-tested. The report shall include the annotated PVT Plan used during the PVT. Where problems were identified, explain each problem and the corrective action taken. Include a written certification that the installation and testing of the control system is complete and meets all of the contract's requirements.

3.5 TRAINING REQUIREMENTS

Provide a qualified instructor (or instructors) with two years minimum field experience with the installation and programming of similar BACnet DDC systems. Orient training to the specific systems installed. Coordinate training times with the Contracting Officer and BAS Owner after receiving approval of the training course documentation. Training shall take place at the job site and/or a nearby Government-furnished location.

A training day shall occur during normal working hours, last no longer than 8 hours and include a one-hour break for lunch and two additional 15-minute breaks. The project's approved Controls System Operators Manual shall be used as the training text. The Contractor shall ensure the manuals are submitted, approved, and available to hand out to the trainees before the start of training.

3.5.1 Training Documentation

Submit training documentation for review 30 days minimum before training. Documentation shall include an agenda for each training day, objectives, a synopses of each lesson, and the instructor's background and qualifications. The training documentation can be submitted at the same time as the project's Controls System Operators Manual.

3.5.2 Phase I Training - Fundamentals

The Phase I training session shall last two consecutive days and be conducted in a classroom environment with complete audio-visual aids provided by the contractor. Provide each trainee a printed 8.5 by 11 inch hard-copy of all visual aids used. Upon completion of the Phase I Training, each trainee should fully understand the project's DDC system fundamentals. The training session shall include the following:

a. BACnet fundamentals (objects, services, addressing) and how/where they are used on this project

b. This project's list of control system components

c. This project's list of points and objects

d. This project's device and network communication architecture

e. This project's sequences of control, and:

f. Alarm capabilities

g. Trending capabilities

h. Troubleshooting communication errors

i. Troubleshooting hardware errors

3.5.3 Phase II Training - Operation

Provide Phase II Training shortly after completing Phase I Training. The Phase II training session shall last two consecutive days and be conducted at the DDC system workstation, at a notebook computer connected to the DDC system in the field, and at other site locations as necessary. Upon completion of the Phase II Training, each trainee should fully understand the project's DDC system operation. The training session shall include the following:

a. A walk-through tour of the mechanical system and the installed DDC components (controllers, valves, dampers, surge protection, switches, thermostats, sensors, etc.)

b. A discussion of the components and functions at each DDC panel

c. Logging-in and navigating at each operator interface type

d. Using each operator interface to find, read, and write to specific controllers and objects

e. Modifying and downloading control program changes

f. Modifying setpoints

g. Creating, editing, and viewing trends

h. Creating, editing, and viewing alarms

i. Creating, editing, and viewing operating schedules and schedule objects

j. Backing-up and restoring programming and data bases

k. Modifying graphic text, backgrounds, dynamic data displays, and links to other graphics

l. Creating new graphics and adding new dynamic data displays and links

m. Alarm and Event management

n. Adding and removing network devices

-- End of Section --

SECTION 23 09 23

LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating
AMCA 511	(2013) Certified Ratings Program for Air Control Devices

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE FUN IP	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, SI Edition

ASME INTERNATIONAL (ASME)

ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A269/A269M	(2014; E 2014) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless

	Copper Water Tube (Metric)
ASTM D1693	(2013) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2004) Free-Topology Twisted-Pair Channel Specification
CEA-852-C	(2014) Tunneling Component Network Protocols Over Internet Protocol Channels

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2	(2013) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 4361	(2006) Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4
LonMark SCPT List	(2003) LonMark SCPT Master List; Version 12
LonMark SNVT List	(2003) LonMark SNVT Master List; Version 113
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.402

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.20	(2010) Electricity Meters - 0.2 and 0.5 Accuracy Classes
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 5085-3	(2006; Reprint Nov 20121) Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers
UL 555	(2006; Reprint May 2014) Standard for Fire Dampers
UL 555S	(2014) Smoke Dampers
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment
UL 94	(2013; Reprint Sep 2014) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes

1.2 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in the Section but are included here for completeness.

a. Application Generic Controller (AGC): A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the ProgramID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

b. Application Specific Controller (ASC): A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

c. Binary: A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

d. Binding: The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent.

e. Building Control Network (BCN): The CEA-709.1-D control network consisting of one or more TP/FT-10 channels, and possibly a single TP/XF-1250 channel, in doubly terminated bus topology.

f. Building Point of Connection (BPOC): The BPOC is the point of connection between the UMCS network backbone (an IP network) and the building control network backbone. The hardware at this location, which provides the connection, is referred to as the BPOC Hardware. In general, the term "BPOC Location" means the place where this connection occurs, and "BPOC Hardware" means the device that provides the connection. Sometimes the term "BPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

g. Channel: A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

h. Commandable: See Overridable.

i. Configuration Property: Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see 'Standard Configuration Property Type (SCPT)'

j. Control Logic Diagram: A graphical representation of control logic for multiple processes that make up a system.

k. Domain: A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) See also Node Address.

l. Explicit Messaging: A non-standard and often vendor (application) specific method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received.

m. External Interface File (XIF): A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

n. Functional Profile: A standard description, defined by LonMark, of one or more LonMark Objects used to classify and certify devices.

o. Gateway: A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

p. General Purpose Programmable Controller (GPPC): Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed ProgramID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the ProgramID will change..

q. LonMark Object: A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

r. LNS Plug-in: Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a 'user friendly' method to edit a device's configuration properties.

s. LonMark: See LonMark International. Also, a certification issued by LonMark International to CEA-709.1-D devices.

t. LonMark International: Standards committee consisting of numerous independent product developers, system integrators and end users dedicated to determining and maintaining the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

u. LonMark Interoperability Association: See 'LonMark International'.

v. LonWorks: The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), (including the protocol itself, network management, interoperability guidelines and products.

w. LonWorks Network Services (LNS): A network management and database standard for CEA-709.1-D devices.

x. Monitoring and Control (M&C) Software: The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

y. Network Variable: See 'Standard Network Variable Type (SNVT)'.

z. Network Configuration Tool: The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

aa. Node: A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

bb. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

cc. Node ID: A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

dd. Overridable: A point is overridable if its value can be changed using network variables outside of the normal sequence of operations where this change has priority over the sequence. Typically this override is from the Utility Monitoring and Control System (UMCS) Monitoring and Control (M&C) Software. Note that that this definition is not standard throughout industry; some refer to this capability as "commandable" and some use this term to refer to changing a value from a configuration tool.

ee. Polling: A device requesting data from another device.

ff. Program ID: An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

gg. Repeater: A device that connects two control network segments and retransmits all information received on one side onto the other.

hh. Router: A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

ii. Segment: A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

jj. Service Pin: A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID. This broadcast can also be initiated via software.

kk. Standard Configuration Property Type (SCPT): Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Properties.

ll. Standard Network Variable Type (SNVT): Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

mm. Subnet: Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also Node Address.

nn. TP/FT-10: A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

oo. TP/XF-1250: A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

pp. UMCS Network: An IP network connecting multiple building control networks (BCNs) to the Monitoring and Control Software using the CEA-852-C standard.

qq. User-defined Configuration Property Type (UCPT): Pronounced 'u-keep-it'. A Configuration Property format type that is defined by the device manufacturer.

rr. User-defined Network Variable Type (UNVT): A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.3 SYSTEM DESCRIPTION

The Direct Digital Control (DDC) system shall be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown.

1.3.1 System Requirements

Systems installed under this specification shall have the following characteristics:.

a. The control system shall be an open implementation of LonWorks technology using CEA-709.1-D as the communications protocol and using LonMark Standard Network Variable Types as defined in LonMark SNVT List exclusively for communication over the network.

b. LonWorks Network Services (LNS) shall be used for all network management including addressing and binding of network variables. Submit to the project site two copies of the complete, fully-commissioned, valid, as-built Final LNS database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Each copy shall be on CD-ROM and shall be clearly marked identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification. The submitted LNS Database shall consist of the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. All devices shall be on-line and commissioned into the LNS database.

c. The hardware shall perform the control sequences as specified and shown and provide control of the equipment as specified and shown.

d. Control sequence logic shall reside in DDC hardware in the building. The building control network shall not be dependent upon connection to a Utility Monitoring and Control System (UMCS) for performance of control sequences in this specification. The hardware shall, to the greatest extent practical, perform the sequences without reliance on the building network.

e. The hardware shall be installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

f. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

g. Provide sufficient documentation and data, including rights to documentation and data, such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

h. Hardware shall be installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor.

i. Control hardware shall be installed and configured to provide all input and output Standard Network Variables (SNVTs) as shown and as needed to meet the requirements of this specification.

j. All DDC devices installed under this specification shall communicate via CEA-709.1-D. The control system shall be installed such that a SNVT output from any node on the network can be bound to any other node in the domain.

1.3.2 Verification of Dimensions

After becoming familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.3.3 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.3.4 Data Packages/Submittals Requirements

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and be delivered with unrestricted rights.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES, and TABLE I. PROJECT SEQUENCING:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G
Draft As-Built Drawings; G
Final As-Built Drawings; G

SD-03 Product Data

Manufacturer's Catalog Data; G
Programming Software; G
GPPC Application Programs; G
AGC Application Programs; G
XIF files; G
Draft LNS Database; G
Final LNS Database; GLNS Plug-in; G

SD-06 Test Reports

Existing Conditions Report; G
Start-Up and Start-Up Testing Report; G
PVT Procedures; G
PVT Report; G
Pre-Construction QC Checklist; G
Post-Construction QC Checklist; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G
Training Documentation; G

SD-11 Closeout Submittals

Closeout QC Checklist; G

1.5 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING lists the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column). TABLE I does not specify overall project milestone and completion dates; these dates are specified in the contract documents.

a. Sequencing for submittals: The sequencing specified for submittals is the deadline by which the submittal shall be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon resubmittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	
3	S	Manufacturer's Catalog Data	
4	S	Network Bandwidth Usage Calculations	
5	S	Pre-construction QC Checklist	
6	E	Install Building Control System	AAO #1 thru #5
7	E	Start-Up and Start-Up Testing	ACO #6
8	S	Post-Construction QC Checklist	30 days ACO #7
9	S	Programming Software	30 days ACO #7
10	S	XIF Files	30 days ACO #7
11	S	LNS Plug-ins	30 days ACO #7
12	S	Start-Up and Start-Up Testing Report	10 days ACO #7

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
13	S	Draft As-Built Drawings	15 days ACO #7
14	S	Draft LNS Database	15 days ACO #7
15	S	PVT Procedures	10 days before scheduled start of #16 and AAO #12
16	E	PVT	AAO #13, #14 and #15
17	S	PVT Report	10 days ACO #16
18	S	GPPC Application Programs and AGC Application Programs	10 days AAO #17
19	S	Final LNS Database	10 days AAO #17
20	S	Final As-Built Drawings	10 days AAO #17
21	S	O&M Instructions	AAO #20
22	S	Training Documentation	AAO #12 and 15 days before scheduled start of #23
23	E	Training	AAO #21 and #22
24	S	Closeout QC Checklist	ACO #23

1.6 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative shall complete the QC Checklist in APPENDIX A and submit one hard copy & one digital copy (.pdf - text searchable) of Pre-Construction QC Checklist, Post-Construction QC Checklist and Closeout QC Checklist. The QC Representative shall verify each item in the Checklist and initial in the provided area to indicate that the requirement has been met. The QC Representative shall sign and date the Checklist prior to submission to the Government.

1.7 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit one hard copy & one digital copy (.pdf - text searchable) of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions shall be a single volume or in separate volumes, and may be submitted as a Technical Data Package. The HVAC control System Operation and Maintenance Instructions shall include:

a. "Manufacturer Data Package 3" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA for each piece of control equipment.

b. "Manufacturer Data Package 4" as described in Section 01 78 23 OPERATION AND MAINTENANCE DATA for all air compressors.

c. HVAC control system sequences of operation formatted as specified.

d. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.

e. As-built HVAC control system detail drawings formatted as specified.

f. A list of the configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

h. Qualified service organization list.

i. Start-Up and Start-Up Testing Report.

j. Performance Verification Test (PVT) Procedures and Report.

1.9 SURGE PROTECTION

1.9.1 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.9.2 Surge Protection for Transmitter and Control Wiring

DDC hardware shall be protected against or withstand surges induced on control and transmitter wiring installed outdoors and as shown. The equipment protection shall be protected against the following two waveforms:

a. A waveform with a 10-microsecond rise time, a 1,000-microsecond decay time and a peak current of 60 amps.

b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

1.10 INPUT MEASUREMENT ACCURACY

Sensors, transmitters and DDC Hardware shall be selected, installed and configured such that the maximum error of the measured value at the SNVT output of the DDC hardware is less than 105 percent of the maximum allowable error specified for the sensor or instrumentation.

PART 2 PRODUCTS

PART 2 of this specification covers requirements for Products (equipment). Installation requirements for these products are covered in PART 3 of this specification.

2.1 EQUIPMENT

2.1.1 General Requirements

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use shall include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement shall be acceptable provided it has been successfully used by the Contractor in a minimum of two previous projects. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Manufacturer's catalog data sheets documenting compliance with product specifications shall be submitted as specified for each product installed under this specification.

2.1.2 Operation Environment Requirements

Unless otherwise specified, all products shall be rated for continuous operation under the following conditions:

a. Pressure: Pressure conditions normally encountered in the installed location.

b. Vibration: Vibration conditions normally encountered in the installed location.

c. Temperature:

(1) Products installed indoors: Ambient temperatures in the range of 0 to 50 degrees C (32 to 112 degrees F) and temperature conditions outside this range normally encountered at the installed location.

(2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of -37 to +66 degrees C (-35 to +151 degrees F) and temperature conditions outside this range normally encountered at the installed location.

d. Humidity: 10 to 95 percent relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.2 ENCLOSURES AND WEATHERSHIELDS

2.2.1 Enclosures

Enclosures shall meet the following minimum requirements, unless otherwise indicated in drawings:

a. Outdoors: Enclosures located outdoors shall meet NEMA 250 Type 3 or Type 4 requirements.

b. Mechanical and Electrical Rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 or Type 4 requirements.

c. Other Locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings, and plenum returns shall meet NEMA 250 Type 1 requirements.

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable.

2.2.2 Weathershields

Weathershields for sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the sensor. Weathershields installed near outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the sensor. Weathershields shall be constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

2.3 TUBING

2.3.1 Copper

Copper tubing shall conform to ASTM B88, ASTM B88M and KS D 5301

2.3.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A269/A269M

2.3.3 Plastic

Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D635, shall have UL 94 V-2 flammability classification or better, and shall withstand stress cracking when tested in accordance with ASTM D1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.4 NETWORK HARDWARE

2.4.1 CEA-709.1-D Network Routers

CEA-709.1-D Routers (including routers configured as repeaters) shall meet the requirements of CEA-709.1-D and shall provide connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.

2.4.2 Gateways

Gateways shall perform bi-directional protocol translation from one non-CEA-709.1-D protocol to CEA-709.1-D. Gateways shall incorporate a network connection to a TP/FT-10 network in accordance with CEA-709.3 and a connection for a non-CEA-709.1-D network.

2.4.3 CEA-709.1-D to IP Router

CEA-709.1-D to IP Routers shall perform layer 3 routing of CEA-709.1-D packets over an IP network in accordance with CEA-852-C. The router shall provide the appropriate connection to the IP network and connections to the CEA-709.3 TP/FT-10 or TP/XF-1250 network. CEA-709.1-D to IP Routers shall support the Dynamic Host Configuration Protocol (DHCP; IETF RFC 4361 for IP configuration and the use of a CEA-852-C Configuration Server (for CEA-852-C configuration), but shall not rely on these services for configuration. CEA-709.1-D to IP Routers shall be capable of manual configuration via a console RS-232 port.

2.5 WIRE AND CABLE

All wire and cable shall meet the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification.

2.5.1 Terminal Blocks

Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.5.2 Control Network Wiring

Control network wiring shall be twisted pair in accordance with CEA-709.3.

2.5.3 Control Wiring for Binary Signals

Control wiring for binary signals shall be 18 AWG copper and shall be rated for 300-volt service.

2.5.4 Control Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.

2.5.5 Control Wiring for Analog Signals

Control Wiring for Analog Signals shall be 18 AWG, copper, single- or multiple-twisted, minimum 50 mm (2 inch) lay of twist, 100% shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.5.6 Transformers

Transformers shall be UL 5085-3 approved. Transformers shall be sized so that the connected load is no greater than 80% of the transformer rated capacity.

2.6 AUTOMATIC CONTROL VALVES

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150% of the system design operating pressure. Unless otherwise specified or shown, valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01% of valve Kv). Unless otherwise specified or shown, valves shall have globe-style bodies. Unless otherwise specified:

a. bodies for valves smaller than 50 mm (2 inches) shall be brass or bronze, with threaded or union ends

b. bodies for 50 mm (2 inch) valves shall have threaded ends

c. bodies for valves 50 to 80 mm (2 to 3 inches) shall be of brass, bronze or iron.

d. bodies for valves larger than 50 mm (2 inches) shall be provided with flanged-end connections.

e. for modulating applications, valve Kv (Cv) shall be within 100 to 125% of the Kv (Cv) shown.

f. for two position applications (where the two positions are full open and full closed) the Kv (Cv) shall be the largest available for the valve size.

f. valve and actuator combination shall be normally open or normally closed as shown.

2.6.1 Ball Valves

Balls shall be stainless steel or nickel plated brass. Valves shall have blow-out proof stems. In steam and high temperature hot water applications, the valve-to-actuator linkage shall provide a thermal break.

2.6.2 Butterfly Valves

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies or with ductile iron bodies in accordance with ASTM A536. Butterfly valves shall have non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -29 to +121 degrees C (-20 to +250 degrees F). The rated Kv (Cv) for butterfly valves shall be the value Kv (Cv) at 70 percent (60 degrees) open position. Valve leakage shall meet FCI 70-2 Class VI leakage rating.

2.6.3 Two-Way Valves

Two-way modulating valves used for liquids shall have an equal-percentage characteristic. Two-way modulating valves used for steam shall have a linear characteristic.

2.6.4 Three-Way Valves

Three-way modulating valves shall provide equal percentage flow control with constant total flow throughout full plug travel.

2.6.5 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be provided for each flare-type end valve.

2.6.6 Valves for Chilled-Water, Condenser-Water, and Glycol Service

Valve internal trim shall be Type 316 stainless steel. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.6.7 Valves for High-Temperature Water, Hot-Water and Dual Temperature Service

a. Valves for hot water service between 99 and 121 degrees C (210 and 250 degrees F) and dual-temperature service shall have internal trim (including seats, seat rings, modulating plugs, and springs) of Type 316 stainless steel. Internal trim for valves controlling water below 99 degrees C (210 degrees F) shall be brass, bronze or Type 316 stainless steel. Nonmetallic valve parts shall be suitable for a minimum continuous operating temperature of 121 degrees C or 28 degrees C (250 degrees F or 50 degrees F) above the system design temperature, whichever is higher. Valves 100 mm (4 inches) and larger shall be butterfly valves.

b. For high-temperature hot water service above 121 degrees C (250 degrees F) valve bodies shall be carbon steel, globe type with welded ends on valves 25 mm (1 inch) and larger. Valves smaller than 25 mm (1 inch) shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE). Internal valve trim shall be Type 316 stainless steel.

2.6.8 Valves for Steam Service

Bodies for valves 100 mm (4 inches) and larger shall be iron or carbon steel. Internal valve trim shall be Type 316 stainless steel. If the specified Kv (Cv) is not available the valve manufacturer's next largest size shall be used.

2.7 DAMPERS

2.7.1 Damper Assembly

A single damper section shall have blades no longer than 1.2 m (48 inch) and shall be no higher than 1.8 m (72 inch). Maximum damper blade width shall be 203 mm (8 inch). Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 13 mm (1/2 inch) minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings.

Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 10 Pa (0.04 inches water gauge) at 5.1 m/s (1,000 ft/min) in the wide-open position. Frames shall not be less than 50 mm (2 inch) in width. Dampers shall be tested in accordance with AMCA 500-D.

2.7.2 Operating Linkages

Operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least 300% of the maximum required damper-operating force without deforming. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crank arms shall control the open and closed positions of dampers.

2.7.3 Damper Types

2.7.3.1 Flow Control Dampers

Outside air, return air, relief air, exhaust, face and bypass dampers shall be provided where shown and shall be parallel-blade or opposed blade type as shown on the Damper Schedule. Blades shall have interlocking edges. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Unless otherwise shown, dampers shall meet AMCA 511 Class 1A, Class 1, or Class 2 requirements, as indicated in drawings. Outside air damper seals shall be suitable for an operating temperature range of -40 to +75 degrees C (-40 to +167 degrees F). Dampers shall be rated at not less than 10 m/s (2000 ft/min) air velocity.

2.7.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Utility space ventilation dampers shall be as shown. Unless otherwise shown, dampers shall be AMCA 511 class 3. Dampers shall be rated at not less than 7.6 m/s (1500 ft/min) air velocity.

2.7.3.3 Smoke Dampers

Smoke-damper and actuator assembly shall meet the current requirements of NFPA 90A, UL 555, and UL 555S. Combination fire and smoke dampers shall be rated for 121 degrees C (250 degrees F) Class II leakage per UL 555S.

2.8 SENSORS AND INSTRUMENTATION

Unless otherwise specified, sensors and instrumentation shall incorporate an integral transmitter or be provided with a transmitter co-located with the sensor. Sensors and instrumentation, including their transmitters, shall meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion. Sensors and instrumentation, including their transmitters, shall meet or exceed the specified range.

2.8.1 Transmitters

The transmitter shall match the characteristics of the sensor. Transmitters providing analog values shall produce a linear 4-20 mAdc, 0-10 Vdc or SNVT output corresponding to the required operating range and shall have zero and span adjustment. Transmitters providing binary values shall have dry contacts or SNVT output. Transmitters with SNVT output are Application Specific Controllers (ASCs) and shall meet all ASC requirements. (note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE)

2.8.2 Temperature Sensors

2.8.2.1 Sensor Ranges and Accuracy

Temperature sensors may be provided without transmitters. Temperature sensors, including transmitter if used, shall have minimum operating ranges, minimum accuracy and maximum drift as specified below for the application:

a. Conditioned Space Temperature

(1) Operating Range: 5 to 35 degrees C (40 to 95 degrees F).

(2) Accuracy: +/- 0.5 degrees C (1 degree F) over the operating range.

(3) Drift: Maximum 0.5 degrees C (1 degree F) per year.

b. Unconditioned Space Temperature

(1) Operating Range: -7 to +66 degrees C (20 to 150 degrees F).

(2) Accuracy: +/- 0.5 degrees C (1 degree F) over the range of -1 to +55 degrees C (30 to 131 degrees F) and +/- 2 degrees C (4 degrees F) over the rest of the operating range.

(3) Drift: Maximum 0.5 degrees C (1 degree F) per year.

c. Duct Temperature

(1) Operating Range: 5 to 60 degrees C (40 to 140 degrees F).

(2) Accuracy: +/- 1 degree C (2 degrees F).

(3) Drift: Maximum 1 degree C (2 degrees F) per year.

d. Outside Air Temperature

(1) Operating Range: -29 to +49 degrees C(-20.2 to 120.2 degrees F).

(2) Accuracy:

(a) +/- 1 degree C (2 degrees F) over the range of -35 to +55 degrees C (-30 to +130 degrees F).

(b) +/- 0.5 degrees C (1 degree F) over the range of -1 to +40 degrees C (30 to 100 degrees F).

(3) Drift: Maximum 0.5 degrees C (1 degree F) per year.

e. High Temperature Hot Water

(1) Operating Range: 65 to 232 degrees C (150 to 450 degrees F).

(2) Accuracy: +/- 2 degrees C (3.6 degrees F).

(3) Drift: Maximum +/- 1 degree C (2 degrees F) per year.

f. Chilled Water

(1) Operating Range: -1 to +38 degrees C (30 to 100 degrees F).

(2) Accuracy: +/- 0.4 degrees C (0.8 degrees F) over the range of 2 to 18 degrees C (35 to 65 degrees F) and +/- 1 degree C (2 degrees F) over the rest of the operating range.

(3) Drift: Maximum 0.4 degrees C (0.8 degrees F) per year.

g. Dual Temperature Water

(1) Operating Range: -1 to +116 degrees C (30 to +240 degrees F).

(2) Accuracy: +/- 1 degree C (2 degrees F).

(3) Drift: Maximum 1 degree C (2 degrees F) per year.

h. Heating Hot Water

(1) Operating Range: 21 to 121 degrees C (70 to 250 degrees F).

(2) Accuracy: +/- 1 degree C (2 degrees F).

(3) Drift: Maximum 1 degree C (2 degrees F) per year.

i. Condenser Water

(1) Operating Range: -1 to +54 degrees C (30 to 130 degrees F).

(2) Accuracy: +/- 0.6 degrees C (1 degree F).

(3) Drift: Maximum 0.6 degrees C (1 degree F) per year.

2.8.2.2 Point Temperature Sensors

Point Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.8.2.3 Averaging Temperature Sensors

Averaging sensors shall be a continuous element at least 3 meters (1 foot) long per square meter (square foot) of duct cross-sectional area at the installed location. The sensing element shall have a bendable copper sheath.

2.8.2.4 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 50 mm (2 inch) lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

2.8.3 Relative Humidity Sensor

Relative humidity sensors shall use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors shall include removable protective membrane filters. Where required for exterior installation, sensors shall be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor shall be capable of being exposed to a condensing air stream (100% RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Sensors used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted sensors shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors shall measure relative humidity over a range of 0% to 100% with an accuracy of +/- 3%. RH sensors shall function over a temperature range of -4 to +55 degrees C (25 to 130 degrees F) and shall not drift more than 2% per year.

2.8.4 Carbon Dioxide (CO2) Sensors

Carbon dioxide (CO2) sensors shall measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersive infrared (NDIR) technology with an accuracy of +/- 75 ppm and a maximum response time of 1 minute. The sensor shall be rated for operation at ambient air temperatures within the range of 0 to 50 degrees C (32 to 122 degrees F) and relative humidity within the range of 0 to 95% (non-condensing). The sensor shall have a maximum drift of 2%. The sensor chamber shall be manufactured with a non-corrosive material (such as gold-plating) that does not affect carbon dioxide sample concentration. Duct mounted sensors shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage.

2.8.5 Differential Pressure Instrumentation

2.8.5.1 Differential Pressure Sensors

Differential Pressure Sensor range shall be as shown or as required for the application. Pressure sensor ranges shall not exceed the high end range shown on the Points Schedule by more than 50%. The over pressure rating shall be a minimum of 150% of the highest design pressure of either input to the sensor. The accuracy shall be +/- 2% of full scale.

2.8.5.2 Differential Pressure Switch

The switch shall have a user-adjustable setpoint. The device shall be sized for the application such that the setpoint is between 25% and 75% of the full range. The over pressure rating shall be a minimum of 150% of the highest design pressure of either input to the sensor. The switch shall have two sets of contacts and each contact shall have a rating greater than its connected load. Contacts shall open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as shown.

2.8.6 Flow Sensors

2.8.6.1 Airflow Measurement Array (AFMA)

a. Airflow Straightener. AFMAs shall contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener shall be contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation, airflow straighteners shall be provided if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, shall be constructed of 3 mm (0.125 inch) aluminum honeycomb and the depth of the straightener shall not be less than 40 mm (1.5 inches).

b. Resistance to airflow. The resistance to air flow through the AFMA, including the airflow straightener shall not exceed 20 Pa (0.08 inch water gauge) at an airflow of 10 m/s (2,000 fpm). AFMA construction shall be suitable for operation at airflows of up to 25 m/s (5,000 fpm) over a temperature range of 4 to 49 degrees C (40 to 120 degrees F).

c. Outside air temperature. In outside air measurement or in low-temperature air delivery applications, the AFMA shall be certified by the manufacturer to be accurate as specified over a temperature range of -29 to +49 degrees C (-20 +120 degrees F).

d. Pitot Tube AFMA. Each Pitot Tube AFMA shall contain an array of velocity sensing elements. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the AFMA manufacturer.

(1) Pitot Tube AFMAs for use in airflows over 3.0 m/s (600 fpm) shall have an accuracy of +/- 5% over a range of 2.5 to 12.5 m/s (500 to 2,500 fpm).

(2) Pitot Tube AFMAs for use in airflows under 3.0 m/s (600 fpm) shall have an accuracy of +/- 5% over a range of 0.6 to 12.5 m/s (125 to 2,500 fpm).

e. Electronic AFMA. Each electronic AFMA shall consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published application data of the AFMA manufacturer. Electronic AFMAs shall have an accuracy of +/- 5% percent over a range of 0.6 to 12.5 m/s (125 to 2,500 fpm) and the output shall be temperature compensated over a range of 0 to 100 degrees C (32 to 212 degrees F).

2.8.6.2 Orifice Plate

Orifice plate shall be made of an austenitic stainless steel sheet of 3.3 mm (0.125 inch) nominal thickness with an accuracy of +/- 1% of full flow. The orifice plate shall be flat within 0.1 mm (0.002 inches). The orifice surface roughness shall not exceed 0.5 micro-meters (20 micro-inches). The thickness of the cylindrical face of the orifice shall not exceed 2% of the pipe inside diameter or 12.5% of the orifice diameter, whichever is smaller. The upstream edge of the orifice shall be square and sharp. Where orifice plates are used, concentric orifice plates shall be used in all applications except steam flow measurement in horizontal pipelines.

2.8.6.3 Flow Nozzle

Flow nozzle shall be made of austenitic stainless steel with an accuracy of +/- 1% of full flow. The inlet nozzle form shall be elliptical and the nozzle throat shall be the quadrant of an ellipse. The thickness of the nozzle wall and flange shall be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline shall not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing shall be such that the nozzle throat shall be centered accurately in the pipe.

2.8.6.4 Venturi Tube

Venturi tube shall be made of cast iron or cast steel and shall have an accuracy of +/- 1% of full flow. The throat section shall be lined with austenitic stainless steel. Thermal expansion characteristics of the lining shall be the same as that of the throat casting material. The surface of the throat lining shall be machined to a +/- 1.2 micrometer (50 micro inch) finish, including the short curvature leading from the converging entrance section into the throat.

2.8.6.5 Annular Pitot Tube

Annular pitot tube shall be made of austenitic stainless steel with an accuracy of +/- 2% of full flow and a repeatability of +/- 0.5% of measured value. The unit shall have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.8.6.6 Insertion Turbine Flowmeter

Insertion Turbine Flowmeter accuracy shall be +/- 1% of reading for a minimum turndown ratio of 1:1 through a maximum turndown ratio of 50:1. Repeatability shall be +/- 0.25% of reading. The meter flow sensing element shall operate over a range suitable for the installed location with a pressure loss limited to 1% of operating pressure at maximum flow rate. Design of the flowmeter probe assembly shall incorporate integral flow, temperature, and pressure sensors. The turbine rotor assembly shall be constructed of Series 300 stainless steel and use Teflon seals.

2.8.6.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy shall be within +/- 0.8% of the actual flow. The flow meter body shall be made of austenitic stainless steel. The vortex shedding flowmeter body shall not require removal from the piping in order to replace the shedding sensor.

2.8.6.8 Positive Displacement Flow Meter

The flow meter shall be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service as shown. A counter shall be mounted on top of the meter, and shall consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer shall have a six digit register to indicate the volume passed through the meter in liters or gallons, and a sweep-hand dial to indicate down to 1 liter (0.25 gallons). The pulse transmitter shall have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter shall have a bronze body with threaded or flanged connections as required for the application. Output accuracy shall be +/- 2% of the flow range. The maximum pressure drop at full flow shall be 34 kPa (5 psig).

2.8.6.9 Flow Meters, Paddle Type

Sensor shall be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy shall be +/- 2% of rate of flow, minimum operating flow velocity shall be 0.3 meters/second (1 foot per second). Sensor repeatability and linearity shall be +/- 1%. Materials which will be wetted shall be made from non-corrosive materials and shall not contaminate water. The sensor shall be rated for installation in pipes of 76 mm to 1 m (3 to 40 inch) diameters. The transmitter housing shall be a NEMA 250 Type 4 enclosure.

2.8.6.10 Flow Switch

Flow switch shall have a repetitive accuracy of +/- 10% of actual flow setting. Switch actuation shall be adjustable over the operating flow range, and shall be sized for the application such that the setpoint is between 25% and 75% of the full range. The switch shall have Form C snap-action contacts, rated for the application. The flow switch shall have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system shall be rated for use in corrosive environments encountered.

2.8.6.11 Gas Utility Flow Meter

Gas utility flow meter shall be diaphragm or bellows type (gas positive displacement meters) for flows up to 19.7 L/sec (2500 SCFH) and axial flow turbine type for flows above 19.7 L/sec (2500 SCFH), designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter shall have a minimum turndown ratio of 10 to 1 with an accuracy of +/- 1% of actual flow rate. The meter index shall include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output shall not require field adjustment or calibration. The electrical impulse dry contact output shall have a minimum resolution of 3 cubic meters (100 cubic feet) of gas per pulse and shall not exceed 15 pulses per second at the design flow.

2.8.7 Electrical Instruments

Electrical Instruments shall have an input range as shown or sized for the application. Unless otherwise specified, AC instrumentation shall be suitable for 60 Hz operation.

2.8.7.1 Watt or Watthour Transducers

Watt transducers shall measure voltage and current and shall output kW or kWh or both kW and kWh as shown. kW outputs shall have an accuracy of +/- 0.25 percent over a power factor range of 0.1 to 1. kWh outputs shall be SNVT outputs or pulse outputs and shall have an accuracy of +/- 0.5% over a power factor range of 0.1 to 1.

2.8.7.2 Watthour Revenue Meter (with and without Demand Register)

All Watthour revenue meters shall measure voltage and current and shall be in accordance with ANSI C12.1 with an ANSI C12.20 Accuracy class of 0.5

and shall have pulse initiators for remote monitoring of Watthour consumption. Pulse initiators shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with NEMA/ANSI C12.10. Watthour revenue meters with demand registers shall have an analog output or SNVT output for instantaneous demand in addition to the pulse initiators.

2.8.7.3 Current Transducers

Current transducers shall accept an AC current input and shall have an accuracy of +/- 2percent of full scale. The device shall have a means for calibration.

2.8.7.4 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) shall provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays shall be of split-core design. The CSR shall be rated for operation at 200% of the connected load. Voltage isolation shall be a minimum of 600 volts. The CSR shall auto-calibrate to the connected load.

2.8.7.5 Voltage Transducers

Voltage transducers shall accept an AC voltage input and have an accuracy of +/- 0.25% of full scale. The device shall have a means for calibration. Line side fuses for transducer protection shall be provided.

2.8.8 pH Sensor

The sensor shall be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories shall be corrosion and chemical resistant with fittings for tank or suspension installation. Housing shall be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor shall be encapsulated. Periodic replacement shall not be required for continued sensor operation. Sensors shall use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 689 kPa at 66 degrees C (100 psig at 150 degrees F). The reference cell shall be double junction configuration. Sensor range shall be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of +/- 0.05 pH value, response of 90% of full scale in one second and a linearity of 99% of theoretical electrode output measured at 24 degrees C (76 degrees F).

2.8.9 Oxygen Analyzer

Oxygen analyzer shall consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer shall be equipped with filters to remove flue air particles. Sensor probe temperature rating shall be 435 degrees C (815 degrees F). The sensor assembly shall be equipped for flue flange mounting.

2.8.10 Carbon Monoxide Analyzer

Carbon monoxide analyzer shall consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting shall be provided. Both assemblies shall include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer shall be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices shall be provided. Unit measurement range shall not exceed specified range by more than 50%. Repeatability shall be +/- 2% of full scale with an accuracy of +/- 3% of full scale.

2.8.11 Occupancy Sensors

Occupancy sensors shall have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes. Occupancy sensors shall be rated for operation in ambient air temperatures ranging from 5 to 35 degrees C (40 to 95 degrees F) or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches shall have an auto-off switch. Wall switch sensors shall be decorator style and shall fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs shall be UL listed. In addition to any outputs required for lighting control, the occupancy sensor shall provide a dry contact output rated at 1A at 24 Vac or a SNVT output.

2.8.11.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors shall have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 6 meters (20 feet) unless otherwise shown or specified. PIR Sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors shall be immune to false triggering from RFI and EMI.

2.8.11.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors shall operate at a minimum frequency 32 kHz and shall be designed to not interfere with hearing aids.

2.8.11.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors shall meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.8.12 Vibration Switch

Vibration switch shall be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit shall have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range shall be a true rms reading, suitable for the application. The unit shall include either displacement response for low speed or velocity response for high speed application. The frequency range shall be at least 2 Hz to 200 Hz. Contact time delay shall be 3 seconds. The unit shall have independent start-up and running delay on each switch contact. Alarm limits shall be adjustable and setpoint accuracy shall be +/- 10% of setting with repeatability of plus or minus 2%.

2.8.13 Conductivity Sensor

Sensor shall include local indicating meter and shall be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as shown. Sensor shall sense from 0 to 10 microSeimens per centimeter (uS/cm) for distillation systems, 0 to 100 uS/cm for boiler, chilled water, and potable water systems and 0 to 1000 uS/cm for condenser water systems. Contractor shall field verify the ranges for particular applications and adjust the range as required. Contractor shall submit a complete water quality analysis of a sample of the process to be monitored with the submittal of the sensor manufacturer's catalog data. The output shall be temperature compensated over a range of 0 to 100 degrees C (32 to 212 degrees F). The accuracy shall be +/- 2% of the full scale reading. Sensor shall have automatic zeroing and shall require no periodic maintenance or recalibration.

2.8.14 Compressed Air Dew Point Sensor

Sensor shall be suitable for measurement of dew point from -40 +27 degrees C (-40 +80 degrees F) over a pressure range of 0 to 1 MPa (0 to 150 psig). The transmitter shall provide both dry bulb and dew point temperatures on separate outputs. The end to end accuracy of the dew point shall be +/- 2.8 degrees C (5 degrees F) and the dry bulb shall be +/- 0.6 degrees C (1 degree F). Sensor shall be automatic zeroing and shall require no normal maintenance or periodic recalibration.

2.8.15 NOx Monitor

Monitor shall continuously monitor and give local indication of boiler stack gas for NOx content. It shall be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3% oxygen basis and shall have a range of from 0 to 100 ppm. Sensor shall be accurate to +/- 5 ppm. Sensor shall output NOx and oxygen levels and binary output that changes state when the NOx level is above a locally adjustable NOx setpoint. Sensor shall have normal, trouble and alarm lights. Sensor shall have heat traced lines if the stack pickup is remote from the sensor. Sensor shall be complete with automatic zero and span calibration using a timed calibration gas system, and shall not require periodic maintenance or recalibration.

2.8.16 Turbidity Sensor

Sensor shall include a local indicating meter and shall be suitable for measurement of turbidity of water. Sensor shall sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range shall be field-verified for the particular application and adjusted as required. The output shall be temperature compensated over a range of 0 to 100 degrees C (32 to 212 degrees F). The accuracy shall be +/- 5% of full scale reading. Sensor shall have automatic zeroing and shall not require periodic maintenance or recalibration.

2.8.17 Chlorine Detector

The detector shall measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of +/- 1% of full scale and an accuracy of +/- 2% of full scale. The Chlorine Detector transmitter shall be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector shall include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.8.18   Floor Mounted Leak Detector

Leak detectors shall use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 3 mm (0.125 inches). Detector shall have a binary output. The indicator shall be manual reset type.

2.8.19   Temperature Switch

2.8.19.1   Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) shall be manual reset, low temperature safety switches at least 3 meters (1 foot) long per square meter (square foot) of coverage which shall respond to the coldest 450 mm (18 inch) segment with an accuracy of +/- 2 degrees C (3.6 degrees F). The switch shall have a field-adjustable setpoint with a range of at least -1 +10 degrees C (30 to 50 degrees F). The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon drop of temperature below setpoint as shown and shall remain in this state until reset.

2.8.19.2   Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) shall have a field adjustable setpoint between 15 and 32 degrees C (60 and 90 degrees F), an accuracy of +/- 2 degrees C (3.6 degrees F) and a 5 degrees C (10 degrees F) fixed deadband. The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon change of temperature above or below setpoint as shown.

2.8.20   Damper End Switches

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.9   INDICATING DEVICES

All indicating devices shall display readings in metric (SI) units.

2.9.1   Thermometers

Thermometers shall not contain mercury. Unless otherwise specified, thermometers shall have an accuracy of +/- 3% of scale range. Thermometers shall have a range suitable for the application with an upper end of the range not to exceed 150% of the design upper limit.

2.9.1.1   Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 230 mm (9 inch) scale. Piping system thermometers shall have an accuracy of +/- 1% of scale range. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern. Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.9.1.2 Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.9.2 Pressure Gauges

Gauges shall be suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Gauge range shall be suitable for the application with an upper end of the range not to exceed 150% of the design upper limit. Accuracy shall be +/- 3% of scale range. Gauges shall meet requirements of ASME B40.100.

2.9.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 90 mm (3.5 inch) (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range shall be suitable for the application with an upper end of the range not to exceed 150% of the design upper limit. Accuracy shall be plus or minus two percent of scale range.

2.10 OUTPUT DEVICES

Output Devices with SNVT input are ASCs and shall meet all ASC requirements in addition to the output device requirements. (Note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.)

2.10.1 Actuators

Actuators shall be electric (electronic) or pneumatic as shown. All actuators shall be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as shown. Normally open and normally closed actuators shall be of mechanical spring return type. Electric actuators shall have an electronic cut off or other means to provide burnout protection if stalled. Actuators shall have a visible position indicator. Electric actuators shall provide position feedback to the controller as shown. Actuators shall smoothly open or close the devices to which they are applied. Pneumatic actuators shall have a full stroke response time matching the connected Electric to Pneumatic Transducer (EP). Electric actuators shall have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators shall be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators shall provide an output signal identical to its input signal to the additional devices. Pneumatic actuators shall be rated for 172 kPa (25 psi) operating pressure except for high-pressure cylinder-type actuators. All actuators shall be rated for their operating environment. Actuators used outdoors shall be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, shall be submersible.

2.10.1.1 Valve Actuators

Valve actuators shall provide shutoff pressures and torques as shown on the Valve Schedule.

2.10.1.2 Damper Actuators

Damper actuators shall provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque shall be at least 7.3 Nm/square m (6 inch-pounds/1 square foot) of damper area for opposed blade dampers and 10.9 Nm/square m (9 inch-pounds/1 square foot) of damper area for parallel blade dampers.

2.10.1.3 Positive Positioners

Positive positioners shall be a pneumatic relay with a mechanical position feedback mechanism and an adjustable operating range and starting point.

2.10.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) shall accept a voltage input to actuate its air valve. Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection shall be a 10 mm (0.38 inch) NPT threaded connection. Valves shall be rated for 345 kPa (50 psig).

2.10.3 Electric to Pneumatic Transducers (EP)

Electric to Pneumatic Transducers (EPs) shall convert either a 4-20 mAdc input signal, a 0-10 Vdc input signal, or SNVT input to a 21-103 kPa (3-15 psig) pneumatic output with a conversion accuracy of +/- 2% of full scale, including linearity and hysteresis. The EP shall withstand pressures at least 150% of the system supply air pressure (main air). EPs shall include independent offset and span adjustment. Steady state air consumption shall not be greater than 0.024 L/s (0.05 scfm). EPs shall have a manual adjustable override for the EP pneumatic output. EPs shall have sufficient output capacity to provide full range stroke of the actuated device in both directions within 90 seconds.

2.10.4 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts enclosed in a dust proof enclosure. Each set of contacts shall incorporate a normally open (NO), normally closed (NC) and common contact. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

2.11 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons with SNVT output are Application Specific Controllers (ASCs) and shall meet all ASC requirements. (Note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE). Potentiometers shall be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices shall be labeled for their function.

2.12 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device shall meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device shall meet the most stringent of the requirements.

2.12.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion shall meet all requirements of the Current Sensing Relay input device. The Command Switch portion shall meet all requirements of the Relay output device except that it shall have at least one normally-open (NO) contact.

2.12.2 Thermostats

Thermostats shall be multifunction devices incorporating a temperature sensor and one or more of the following as specified and shown on the Thermostat Schedule:

a. A temperature indicating device.

b. A User Input Device which shall adjust a temperature setpoint output.

c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.

d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.

e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..

f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Thermostats shall not contain mercury (Hg).

2.13 COMPRESSED AIR STATIONS

2.13.1 Air Compressor Assembly

The air compressor shall be a high pressure compressing unit with electric motor. The compressor shall be equipped with a motor with totally enclosed belt guard, an operating-pressure switch, safety relief valves, gauges, intake filter and intake silencer, and combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase, and shall be supported by a steel base mounted on an air storage tank. The air compressor shall provide the compressed air required for control operation while operating not more than one-third of the time. The air storage tank shall be fabricated for a working pressure of not less than 1380 kPa (200 psi) and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank shall be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 140 kPa (20 psi). The tank shall be provided with an automatic condensate drain trap with manual override feature. A second (duplex arrangement) compressor of capacity equal to the primary compressor shall be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch shall be provided to index the lead compressor including the automatic changeover.

2.13.2 Compressed Air Station Specialties

2.13.2.1 Refrigerated Dryer, Filters and, Pressure Regulator

A refrigerated dryer shall be provided in the air outlet line of the air storage tank. The dryer shall be of the size required for the full delivery capacity of the compressor. The air shall be dried at a pressure of not less than 483 kPa (70 psi) to a temperature not greater than 2 degrees C (35 degrees F). The dryer shall be provided with an automatic condensate drain trap with manual override feature. The automatic drain trap shall have an adjustable cycle and drain time. The refrigerant used in the dryer shall be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron pre-filter and coalescing-type 0.03 micron oil removal filter with shut-off valves shall be provided in the dryer discharge. Each filter bowl shall be rated for 1034 kPa (150 psi) maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve shall be provided downstream of the filter. Pressure regulators of the relieving type shall not be used.

2.13.2.2 Flexible Pipe Connections

The flexible pipe connections shall be designed for 1034 kPa and 120 degrees C (150 psi and 250 degrees F) service, and shall be constructed of rubber or tetrafluoroethylene resin tubing with a reinforcing protective cover of braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors shall be suitable for the service intended and shall have threaded or soldered ends. The length of the connectors shall be as recommended by the manufacturer for the service intended.

2.13.2.3 Vibration Isolation Units

The vibration isolation units shall be standard products with published loading ratings, and shall be single rubber-in-shear, double rubber-in-shear, or spring type.

2.14 DIRECT DIGITAL CONTROL (DDC) HARDWARE

2.14.1 General Requirements

All DDC Hardware shall meet the following requirements:

a. It shall incorporate a "service pin" which, when pressed will cause the DDC Hardware to broadcast its 48-bit NodeID and its ProgramID over the network. The service pin shall be distinguishable and accessible.

b. It shall incorporate a light to indicate the device is receiving power.

c. It shall incorporate a TP/FT-10 transceiver in accordance with CEA-709.3 and connections for TP/FT-10 control network wiring.

d. It shall communicate on the network using only the CEA-709.1-D protocol.

e. It shall be capable of having network communications configured via LNS.

f. It shall be locally powered; link powered devices are not acceptable.

g. LonMark external interface files (XIF files), as defined in the LonMark XIF Guide, shall be submitted for each type of DDC Hardware. External interface files (XIF files) shall be submitted as a technical data package for each model of DDC Hardware provided under this specification. XIF files shall be submitted on CD-ROM.

h. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings:

(1) Loss of power shall never result in the loss of application programs, regardless of the length of time power is lost (i.e. application programs shall be stored in non-volatile memory).

(2) Loss of power for less than 72 hours shall not result in the loss of configuration settings.

i. It shall have all functionality specified and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to:

(1) It shall provide input and output SNVTs as specified, as shown on the Points Schedule, and as otherwise required to support the sequence and application in which it is used. All SNVTs shall have meaningful names identifying the value represented by the SNVT. Unless a SNVT of an appropriate engineering type is not available, all network variables shall be of a standard network variable type with engineering units appropriate to the value the variable represents.

(2) It shall be configurable via standard configuration properties (SCPTs) as defined in the LonMark SCPT List, user-defined configuration properties (UCPTs), network configuration inputs (ncis) of a SNVT type as defined in the LonMark SNVT List, network configuration inputs (ncis) of a user defined network variable type, or hardware settings on the controller itself for all settings and parameters used by the application in which it is used.

j. It shall meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.

k. In addition to these general requirements and the DDC Hardware Input-Output (I/O) Function requirements, all DDC Hardware shall also meet the requirements of either a Local Display Panel (LDP), Application Specific Requirement (ASC), General Purpose Programmable Controller (GPPC), or Application Generic Controller (AGC). All pieces of DDC Hardware shall have their DDC Hardware Type identified in the Manufacturer's Catalog Data submittal. Where a single device meets the requirements of multiple types, select a single type for that specific device based on its use. One model of DDC hardware may be submitted as different DDC Hardware types when used in multiple applications.

l. The user interface on all DDC Hardware with a user interface shall be password protected against changes.

2.14.2 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions shall meet the following requirements:

a. Analog Inputs: DDC Hardware analog inputs (AIs) shall perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in paragraph INPUT MEASUREMENT ACCURACY. Signal conditioning including transient rejection shall be provided for each analog input. Analog inputs shall be capable of being individually calibrated for zero and span. The AI shall incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

b. Analog Outputs: DDC Hardware analog outputs (AOs) shall perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mAdc or 0-10 Vdc. Analog outputs shall be capable of being individually calibrated for zero and span. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs shall provide for overriding the output to 0% and to 100% or through the range of 0% to 100%

c. Binary Inputs: DDC Hardware binary inputs (BIs) shall accept contact closures and shall ignore transients of less than 5 milli-second duration. Isolation and protection against an applied steady-state voltage up to 180 Vac peak shall be provided.

d. Binary Outputs: DDC Hardware binary outputs (BOs) shall provide relay contact closures or triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs shall provide for overriding the output open or closed.

(1) Relay Contact Closures: Closures shall have a minimum duration of 0.1 second. Relays shall provide at least 180V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be one ampere at 24 Vac.

(2) Triac outputs: Triac outputs shall provide at least 180 V of isolation. Minimum contact rating shall be one ampere at 24 Vac.

e. Pulse Accumulator: DDC Hardware pulse accumulators shall have the same characteristics as the BI. In addition, a buffer shall be provided to totalize pulses. The pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

2.14.3 Local Display Panel (LDP)

The Local Display Panels (LDPs) shall be DDC Hardware with a display and navigation buttons, and shall provide display and adjustment of SNVT inputs and SNVT outputs as shown on the Points Schedule and as specified. The adjustment of SNVTs shall be password protected.

2.14.4 Application Specific Controller (ASC)

Application Specific Controllers (ASCs) have a fixed factory-installed application program (i.e. ProgramID) with configurable settings and do not have the ability to be programmed for custom applications. ASCs shall meet the following requirements in addition to the General DDC Hardware and DDC Hardware Input-Output (I/O) Function requirements:

a. ASCs shall be LonMark Certified.

b. Unless otherwise approved, all necessary Configuration Properties and network configuration inputs (ncis) for the sequence and application in which the ASC is used shall be fully configurable through an LNS plug-in. LNS Plug-ins for each Application Specific Controller and each Application Generic Controller shall be submitted as a Technical Data Package. LNS Plug-ins distributed under a license shall be licensed to the project site. Plug-ins shall be submitted on CD-ROM. Hard copy manuals, if available, shall be submitted for each plug-in provided. This plug-in shall be submitted for each type of ASC (manufacturer and model). (Note: configuration accomplished via hardware settings does not require configuration via plug-in.)

c. ASCs may be include an integral or tethered Local Display Panel

2.14.5 General Purpose Programmable Controller (GPPC)

A General Purpose Programmable Controller (GPPC) may or may not be furnished with a fixed factory-installed application program and must be programmed for the application. GPPCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

a. The programmed GPPC shall conform to the LonMark Interoperability Guide.

b. All programming software required to program the GPPC shall be delivered to and licensed to the project site as specified. Submit the most recent version of the Programming software for each type (manufacturer and model) of General Purpose Programmable Controller (GPPC) as a Technical Data Package. Software shall be submitted on CD-ROM and one hard copy of the software user manual shall be submitted for each piece of software provided.

c. Submit copies of the installed GPPC application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software. The submitted GPPC application program shall be the complete application necessary for the GPPC to function as installed and be sufficient to allow replacement of the installed controller with a GPPC of the same type. All installed GPPC Application Programs shall be submitted on CD-ROM as a Technical Data Package. The CD-ROM shall include a list or table of contents clearly indicating which application program is associated with each device. Submit one copy of the GPPC Application Program's CD-ROM.

d. GPPCs may be include an integral or tethered Local Display Panel

2.14.6 Application Generic Controller (AGC)

An Application Generic Controller (AGC) has a fixed application program which includes the ability to be programmed for custom applications. AGCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

a. The programmed AGC shall conform to the LonMark Interoperability Guide.

b. The AGC shall have a fixed ProgramID and fixed XIF file.

c. Unless otherwise approved, the ACG shall be fully configurable and programmable for the application using one or more LNS plug-ins, all of which shall be submitted as specified for each type of AGC (manufacturer and model).

d. Submit copies of the installed AGC application programs as source code compatible with the supplied programming software LNS plug-in. The submitted AGC application program shall be the complete application program necessary for the AGC to function as installed and be sufficient to allow replacement of the installed controller with an AGC of the same type. All installed AGC Application Programs shall be submitted on CD-ROM as a Technical Data Package. The CD-ROM shall include a list or table of contents clearly indicating which application program is associated with each device. Submit 2 copies of the AGC Application Program's CD-ROM.

e. AGCs may be include an integral or tethered Local Display Panel

PART 3 EXECUTION

3.1 EXISTING CONDITIONS SURVEY

Perform a field survey, including testing and inspection of the equipment to be controlled and submit one hard copy & one digital copy (.pdf - text searchable) of the Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. For those items considered nonfunctional, provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated costs to correct the deficiencies. As part of the report, define the scheduled need date for connection to existing equipment. Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime. Existing devices which are not to be replaced shall be inspected, calibrated, and adjusted as necessary to place them in proper working order.

3.2 CONTROL SYSTEM INSTALLATION

3.2.1 General Installation Requirements

3.2.1.1 HVAC Control System

The HVAC control system shall be completely installed, tested, commissioned, and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.1.2 Device Mounting Criteria

All devices shall be installed in accordance with manufacturer's recommendations and as specified and shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified. Spare thermowells shall be installed adjacent to each thermowell containing a sensor and as shown. Devices located outdoors shall have a weathershield.

3.2.1.3 Labels and Tags

Labels and tags shall be keyed to the unique identifiers shown on the As-Built drawings. All Enclosures and DDC Hardware shall be labeled. All sensors and actuators in mechanical rooms shall be tagged. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Duct static pressure taps shall be tagged at the location of the pressure tap. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may attached using adhesive, but shall not be hand written.

3.2.2 Building Control Network (BCN)

Provide one or more Building Control Networks (BCNs) as required to connect all DDC hardware to a Building Control Network and to meet bandwidth requirements as specified. This requirement may result in multiple BCNs being installed, and unless otherwise specified or necessary to provide required functionality these BCNs may remain separate. Each building control network consists of one or more channels, one of which is the BCN backbone.

3.2.2.1 Building Control Network (BCN) Channel

Each BCN channel shall meet the following requirements:

a. Each channel shall be a TP/FT-10 channel in doubly terminated bus topology in accordance with CEA-709.3.

b. Each channel shall contain no more than 2/3 the maximum number of devices permitted by CEA-709.3.

c. Each channel shall contain no more than 2/3 the maximum number of devices permitted by the manufacturer of the device transceivers. When more than one type of transceiver is used on the same channel the channel shall contain no more than 2/3 of the maximum devices for the transceiver with the lowest maximum.

d. Physical layer repeaters shall not be used.

3.2.2.2 Building Control Network (BCN) Backbone

Each Building Control Network shall have a single BCN Backbone meeting the following requirements:

a. The BCN Backbone shall meet all requirements of a BCN channel except as specified here.

b. When a BCN consist of only a single channel, that channel shall be the Backbone.

c. When a BCN consists of multiple channels, one channel shall be the BCN Backbone, and this channel may be either TP/FT-10 or TP/XF-1250 in accordance with the LonMark Interoperability Guide. The BCN Backbone shall have no devices except CEA-709.1-C Routers connected to it. DDC Hardware shall not be connected to the BCN Backbone when more than one channel is provided.

3.2.2.3 Building Control Network (BCN) Installation

Each building control network shall meet the following requirements:

a. All DDC Hardware shall be connected to a BCN Channel

b. No DDC Hardware shall have more than two CEA-709.1-C Routers between it and a BCN Backbone

c. Each BCN Backbone shall be available at the Building Point of Connection (BPOC) location as shown. When the BPOC location is a room number, provide sufficient additional backbone media to ensure that the BCN Backbone can be extended to any location in the room. Provide a CEA-709.1-C to IP Router in an enclosure or in a lockable enclosure at the BPOC Location as shown and connect the BCN Backbone to it. Do not connect the CEA-709.1-C to IP Router to an IP network.

d. The peak expected bandwidth usage for each and every channel shall be less than 70%, including device-to-device traffic and traffic to the Utility Monitoring and Control System (UMCS) as shown on the Points Schedule. Note that all network traffic to the UMCS is present on the BCN Backbone.

e. The BCN's backbone shall be tagged and labeled at the BPOC location with the expected bandwidth usage and the bandwidth usage measured during the PVT.

f. Where multiple pieces of DDC Hardware are used to execute one sequence all DDC Hardware executing that sequence shall be on a dedicated single channel.

3.2.3 DDC Hardware

DDC hardware shall not be connected to a BCN Backbone if that building control network has more than one channel. Except for DDC Hardware in suspended ceilings, install all DDC Hardware in an enclosure. All DDC Hardware shall be configured and commissioned on the Building Control Network via LNS using an LNS-based Network Configuration Tool. Controllers shall be Application Specific Controllers whenever an Application Specific Controller suitable for the application exists. When an Application Specific Controller suitable for the application does not exist use Application Generic Controllers, General Purpose Programmable Controllers or multiple Application Specific Controllers.

3.2.3.1 Hand-Off-Auto (H-O-A) Switches

Hand-Off-Auto (H-O-A) switches shall be provided for all DDC Hardware analog outputs and binary outputs used for control of systems other than terminal units, as specified and as shown on the Points Schedule. H-O-A switches shall be integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

a. H-O-A switches integral to DDC Hardware shall meet the requirements specified in DDC Hardware.

b. H-O-A switches for binary outputs shall provide for overriding the output open or closed.

c. H-O-A switches for analog outputs shall provide for overriding through the range of 0% to 100%.

3.2.3.2 Local Display Panels

Local Display Panels shall be provided in each mechanical room containing an air handler and shall provide SNVT inputs for display and outputs for adjusting SNVT values as shown on the Points Schedule. Locate LDPs in the mechanical room closest to the equipment providing information displayed by the LDP.

3.2.3.3 Overrides for GPPCs and AGCs

Provide the capability to override points for all General Purpose Programmable Controllers and Application Generic Controllers as specified and as shown on the Points Schedule using one of the following methods:

a. Override SNVT of Same SNVT Type method:

(1) Use this method for all setpoint overrides and for overrides of inputs and outputs whenever practical.

(2) Provide a SNVT input to the DDC hardware containing the point to be overridden of the same SNVT type as the point to be overridden.

(3) Program and configure the DDC hardware such that:

(a) If the value of the SNVT on the override input is the Invalid Value defined for that SNVT by the LonMark SNVT List, then the point is not overridden (its value is determined from the sequence).

(b) If the value of the SNVT on the override input is not the Invalid Value defined for that SNVT by the LonMark SNVT List then set the value of the point to be overridden to the value of the SNVT on the override input.

b. HVAC Override SNVT method:

(1) Use this method for override of inputs and outputs when the "Override SNVT Shares SNVT Type" method is impractical.

(2) Provide a SNVT input to the DDC hardware containing the point to be overridden of SNVT type SNVT_hvac_overid. Show on the Points Schedule how to perform the specified override using this SNVT.

3.2.3.4 Overrides for ASCs

Whenever possible use the methods specified for General Purpose Programmable Controllers and Application Generic Controllers to perform overrides for all Application Specific Controllers. If neither the "Override SNVT of Same SNVT Type" method or "HVAC Override SNVT" method are supported by the Application Specific Controller show this on the Points Schedule and perform overrides as follows:

a. Provide one or more SNVT input(s) to the DDC hardware containing the point to be overridden. Document the number and type of each SNVT provided on the Points Schedule.

b. Configure the Application Specific Controller such that:

(1) For some specific combination or combinations of values at the SNVT override input(s) the point is not overridden, and its value is determined from the sequence as usual. Show on the Points Schedule the values required at the SNVT override input(s) to not override the point.

(2) For other specific combinations of SNVT override input(s), the value of the point to be overridden is determined from the value of the override input(s). Show on the Points Schedule the correlation between the SNVT override input(s) and the resulting value of the overridden point.

3.2.4 Gateways

Gateways may be used for communication with non-CEA-709.1-D control hardware subject to all of the following limitations:

a. Each gateway shall communicate with and perform protocol translation for non-CEA-709.1-D control hardware controlling one and only one package unit.

b. Non-CEA-709.1-D control hardware shall not be used for controlling built-up units.

c. Non-CEA-709.1-D control hardware shall not perform system scheduling functions.

d. Non-CEA-709.1-D network wiring shall be installed only to connect the gateway to the package unit and shall not exceed 3 meters (10 feet) in length.

3.2.5 Network Interface Jack

Provide standard network interface jacks such that each node on the control network is within 3 m (10 ft) of an interface jack. For terminal unit controllers with hardwired thermostats this network interface jack may instead be located at the thermostat. Locating the interface jack at the thermostat or near the controller is preferred. If the network interface jack is other than a 3 mm (1/8 inch) phone jack, provide an interface cable with a standard 3 mm (1/8 inch) phone jack on one end and a connector suitable for mating with installed network interface jack on the other. No more than one type of interface cable shall be required to access all network interface jacks. Contractor shall furnish interface cable(s).

3.2.6 Room Instrument Mounting

Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 1.5 m (60 inches) above the floor unless otherwise shown. Unless otherwise shown on the Thermostat Schedule:

a. Thermostats for Fan Coil Units shall be unit mounted.

b. All other Thermostats shall be wall mounted.

3.2.7 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.2.8 Duct Smoke Detectors

Duct smoke detectors will be provided in supply and return air ducts in accordance with Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. Contractor shall connect the DDC System to the auxiliary contacts provided on the Smoke Detector as required for system safeties and to provide alarms to the DDC system.

3.2.9 Occupancy Sensors

A sufficient quantity of occupancy sensors shall be provided to provide complete coverage of the area (room or space). Occupancy sensors shall be installed in accordance with NFPA 70 requirements and the manufacturer's instructions. Occupancy sensors shall not be located within 1.8 m (6 feet) of HVAC outlets or heating ducts. PIR and dual-technology PIR/ultrasonic sensors shall not be installed where they can "see" beyond any doorway. Ultrasonic sensors shall not be installed in spaces containing ceiling fans. Sensors shall detect motion to within 0.6 m (2 feet) of all room entrances and shall not trigger due to motion outside the room. The off-delay timer shall be set to 15 minutes unless otherwise shown. All sensor adjustments shall be made prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. Each controlled area shall have one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.2.10 Temperature Limit Switch

A temperature limit switch (freezestat) shall be provided to sense the temperature at the location shown. A sufficient number of temperature limit switches (freezestats) shall be installed to provide complete coverage of the duct section. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily. The temperature limit switch (freezestat) sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.

3.2.11 Averaging Temperature Sensing Elements

Sensing elements shall be installed in a serpentine pattern located as shown.

3.2.12 Air Flow Measurement Arrays (AFMA)

Outside Air AFMAs shall be located downstream from the Outside Air filters.

3.2.13 Duct Static Pressure Sensors

The duct static pressure sensing tap shall be located at 75% to 100% of the distance between the first and last air terminal units. If the transmitter output is a 4-20 mA or 0-10Vdc signal, the transmitter shall be located in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units.

3.2.14 Relative Humidity Sensors

Relative humidity sensors in supply air ducts shall be installed at least 3 m (10 feet) downstream of humidity injection elements.

3.2.15 Flowmeters

The minimum straight unobstructed piping for the flowmeter installation shall be at least 10 pipe diameters upstream and at least 5 pipe diameters downstream and in accordance with the manufacturer's installation instructions.

3.2.16 Dampers

3.2.16.1 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators shall not be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.16.2 Damper Installation

Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. Blades shall close completely and leakage shall not exceed that specified at the rated static pressure. Structural support shall be used for multi-section dampers. Acceptable methods include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they shall not sag due to lack of support. Jackshafts shall not be used to link more than three damper sections. Blade to blade linkages shall not be used. Outside and return air dampers shall be installed such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.2.17 Valves

3.2.17.1 Ball Valves

Two-position (open/closed) ball valves may only be used on chilled water, condenser water, hot water, or steam applications. Modulating ball valves may only be used for chilled water and condenser water applications (modulating ball valves shall not be used on steam or hot water applications). In modulating applications a characterizing equal-percentage disc shall be used.

3.2.17.2 Butterfly Valves

In two-way control applications, valve travel shall be limited to 70% (60 degrees) open position.

3.2.18 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible pressure gauge installed in the tubing lines at the actuator as shown.

3.2.19 Wire and Cable

Wire and Cable shall be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding shall be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Test installed ground rods as specified in IEEE 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown. Wiring external to enclosures shall be run in raceways, except low-voltage control and low-voltage network wiring may be installed as follows:

a. plenum rated cable in suspended ceilings over occupied spaces may be run without raceways

b. nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.

3.2.20 Copper Tubing

Copper tubing shall be hard-drawn in exposed areas and either hard-drawn or annealed in concealed areas. Only tool-made bends shall be used. Fittings for copper tubing shall be brass or copper solder joint type except at connections to apparatus, where fittings shall be brass compression type.

3.2.21 Plastic Tubing

Plastic tubing shall be run within covered raceways or conduit except when otherwise specified. Plastic tubing shall not be used for applications where the tubing could be subjected to a temperature exceeding 55 degrees C (130 degrees F). Fittings for plastic tubing shall be for instrument service and shall be brass or acetal resin of the compression or barbed push-on type. Except in walls and exposed locations, plastic multitube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as specified.

3.2.22 Pneumatic Lines

a. Pneumatic lines shall be installed such that they are not exposed to outside air temperatures. Pneumatic lines shall be concealed except in mechanical rooms and other areas where other tubing and piping is exposed.

b. All tubes and tube bundles exposed to view shall be installed neatly in lines parallel to the lines of the building. Tubing in mechanical/electrical spaces shall be routed so that the lines are easily traceable.

c. Air lines shall be purged of dirt, impurities and moisture before connecting to the control equipment. Air lines shall be number coded or color coded and keyed in the As-Built Drawings for future identification and servicing the control system.

3.2.22.1 Pneumatic Lines in Mechanical/Electrical Spaces

In mechanical/electrical spaces, pneumatic lines shall be plastic or copper tubing. Horizontal and vertical runs of plastic tubing or soft copper tubing shall be installed in raceways or rigid conduit dedicated to tubing. Dedicated raceways, conduit, and hard copper tubing not installed in raceways shall be supported every 2 m (6 feet) for horizontal runs and every 2.5 m (8 feet) for vertical runs.

3.2.22.2 Pneumatic Lines External to Mechanical/Electrical Spaces

Tubing external to mechanical/electrical spaces shall be plastic tubing in raceways not containing power wiring or copper with sweat fittings . Raceways and tubing not in raceways shall be supported every 2.5 m (8 feet). Pneumatic lines concealed in walls shall be hard-drawn copper tubing or plastic tubing in rigid conduit. Plastic tubing in a protective sheath, run parallel to the building lines and supported as specified, may be used above accessible ceilings and in other concealed but accessible locations.

3.2.22.3 Terminal Single Lines

Terminal single lines shall be hard-drawn copper tubing, except when the run is less than 300 mm (12 inch) in length, flexible polyethylene may be used.

3.2.22.4 Connection to Liquid and Steam Lines

Tubing for connection of sensing elements and transmitters to liquid and steam lines shall be copper or Series 300 stainless steel with brass compression or stainless-steel compression fittings.

3.2.22.5 Connection to Ductwork

Connections to sensing elements in ductwork shall be plastic tubing.

3.2.22.6 Tubing in Concrete

Tubing in concrete shall be installed in rigid conduit. Tubing in walls containing insulation, fill, or other packing materials shall be installed in raceways dedicated to tubing.

3.2.22.7 Tubing Connection to Actuators

Final connections to actuators shall be plastic tubing no more than 300 mm (12 inches) long and unsupported at the actuator.

3.2.23 Compressed Air Stations

The air compressor assembly shall be mounted on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. The air line shall be connected to the tank with a flexible pipe connector. Compressed air station specialties shall be installed with required tubing, including condensate tubing to a floor drain. Compressed air stations shall deliver control air meeting the requirements of ISA 7.0.01. Foundations and housekeeping pads shall be provided for the HVAC control system air compressors in accordance with the air compressor manufacturer's instructions or as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS.

3.3 DRAWINGS AND CALCULATIONS

Contractor shall prepare and submit shop drawings.

3.3.1 DDC Contractor Design Drawings

One hard copy & one digital copy in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall be assigned a unique identifier as shown. DDC Contractor Design Drawings shall be submitted together as a complete submittal in hard copy and on CDROM in AutoCAD or Microstation format. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Deviations shall be approved by the Contracting Officer. DDC Contractor Design Drawings shall include the following:

a. Drawing Index and HVAC Design Drawing Legend: The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list all Contractor Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The Design Drawing Legend shall show and describe all symbols, abbreviations and acronyms used on the Design Drawings.

b. Valve Schedule: The valve schedule shall contain each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure to torque data, dimensions, and access and clearance requirements data. The valve schedule shall contain actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. A valve schedule shall be submitted for each HVAC system.

c. Damper Schedule: The damper schedule shall contain each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the AMCA 511 maximum leakage rate at the operating static-pressure differential. A damper schedule shall be submitted for each HVAC system.

d. Thermostat and Occupancy Sensor Schedule: The thermostat and occupancy sensor schedule shall contain each thermostat's unique identifier, room identifier and control features and functions as shown. A thermostat and occupancy sensor schedule shall be submitted for each HVAC system.

e. Equipment Schedule: The equipment schedule shall contain the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. An equipment schedule shall be submitted for each HVAC system.

f. Occupancy Schedule: The occupancy schedule drawing shall contain the same fields as the occupancy schedule Contract Drawing with Contractor updated information. An occupancy schedule shall be submitted for each HVAC system.

g. Points Schedule: The Points Schedule drawing shall contain the same fields as the Points Schedule Contract Drawing with Contractor updated information, and at a minimum shall contain: Device address and NodeID, Input and Output SNVTs including SNVT Name, Type and Description, Hardware I/O, including Type (AI, AO, BI, BO) and Description. A Points Schedule shall be submitted for each HVAC system.

h. Compressed Air Station Schematic: The compressed air station schematic diagram shall show all equipment, including: compressor with motor horsepower and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air Compressor and air dryer data shall include calculations of the air consumption of all electric-to-pneumatic transducers and of any other control system devices to be connected to the compressed air station, and the compressed air supply dewpoint temperature at 140 kPa (20 psig). Compressed air station schematic drawings shall be submitted for each compressed air station.

i. Riser diagram of building control network: The Riser Diagram of the Building Control Network may be in tabular form, and shall show all DDC Hardware and all Network Hardware, including network terminators. For each item, provide the unique identifier, common descriptive name, physical sequential order (previous and next device on the network), room identifier and location within room. A single riser diagram shall be submitted for each building control network.

j. Control System Schematics: The control system schematics shall be in the same form as the control system schematic Contract Drawing with Contractor updated information. A control system schematic shall be submitted for each HVAC system.

l. Sequences of Operation including Control Logic Diagrams: The HVAC control system sequence of operation and control logic diagrams shall be in the same format as the Contract Drawings and shall refer to the devices by their unique identifiers. No operational deviations from specified sequences will be permitted without prior written approval of the Government. Sequences of operation and control logic diagrams shall be submitted for each HVAC control system.

m. Controller, Motor Starter and Relay Wiring Diagram: The controller wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system.

3.3.2 Draft As-Built Drawings

Update the Contractor Design Drawings with all as-built data and submit one hard copy & one digital copy of draft as-built drawings. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

3.3.3 Final As-Built Drawings

Update the Draft As-Built Drawings with all final as-built data and submit one hard copy & one digital copy of final as-built drawings. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

3.4 HVAC SYSTEMS SEQUENCES OF OPERATION

3.4.1 Scheduling

3.4.1.1 System Mode

AHUs shall operate in Occupied, Warm-Up-Cool-Down, or Unoccupied modes as specified. VAV boxes, Fan Coils, and other terminal equipment shall operate in Occupied or Unoccupied modes as specified. Chillers, boilers, and other sources of heating/cooling for hydronic loads do not require scheduling; these systems receive requests for heating/cooling from their loads.

3.4.1.2 System Scheduler Requirements

The System Scheduler functionality shall reside in either a piece of DDC Hardware dedicated to this functionality or in the DDC Hardware controlling the system AHU. A single piece of DDC Hardware dedicated to scheduling (performing no other control functionality) may contain multiple System Schedulers. A unique System Scheduler shall be provided for: each AHU including its associated Terminal Units, and each stand-alone Terminal Unit (those not dependent upon AHU service) or group of stand-alone Terminal Units acting according to a common schedule. Each System Scheduler shall provide the following functionality:

a. Scheduled Occupancy Input: Accept network variable of type SNVT_occupancy (as defined in the LonMark SNVT List). Input shall support the following possible values: OC_STANDBY, OC_OCCUPIED and OC_UNOCCUPIED.

b. Occupancy Override Input: Accept network variable of type SNVT_occupancy (as defined in the LonMark SNVT List). Input shall support the following possible values: OC_STANDBY, OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL.

c. Space Occupancy Inputs: For systems with multiple occupancy sensors, accept multiple inputs of network variable type SNVT_Occupancy (as defined in the LonMark SNVT List). Input shall support the following possible values: OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL. For systems with a single occupancy sensor, accept a network variable input of type SNVT_Occupancy or a hardware binary input (BI) indicating the space occupancy status as Occupied or Unoccupied.

d. Air Handler Occupancy Output: For a System Scheduler for a system containing an air handler, output one or more SNVTs indicating the desired occupancy status as one of the following possible values: Warm-Up-Cool-Down (when required by the AHU Sequence of Operation), Occupied and Unoccupied.

e. Terminal Unit Occupancy Output: For a System Scheduler for a stand-alone terminal unit, a group of stand-alone terminal units acting according to a common schedule, or a group of terminal units served by a single air handler, output one or more SNVTs indicating the desired occupancy status as one of the following possible values: Occupied and Unoccupied.

f. Default Schedule: Incorporate a 24-hour 7-day default schedule as shown on the drawings which may be activated and deactivated by the System Scheduler Logic.

g. Communication Determination: Determine the time elapsed between receipts of the scheduled occupancy input SNVT, and use this elapsed time to activate and deactivate the Default Schedule as specified. (This provides the capability for the system scheduler to use its Default Schedule if it loses communication with the UMCS).

3.4.1.3 System Scheduler Output Determination

For controlling an Air Handler, a SNVT input of OC_STANDBY shall be interpreted as Warm-Up-Cool-Down if the sequence of operation supports that mode, otherwise OC_STANDBY shall be interpreted as Occupied. For Terminal Units, OC_STANDBY shall be interpreted as Occupied.

a. Air Handler Occupancy Output: If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, the Air Handler Occupancy Output shall be determined by the default schedule and the Space Occupancy Inputs. Otherwise, the output shall be determined as follows:

(1) If the Override Occupancy Input is not OC_NUL, the Air Handler Occupancy Output shall determined from the Override Occupancy Input.

(2) Otherwise, if at least the required number (as shown on the Occupancy Schedule Drawing) of Space Occupancy Inputs are OC_OCCUPIED or the hardware BI is Occupied the Air Handler Occupancy Output shall be OC_OCCUPIED.

(3) Otherwise, the Air Handler Occupancy Output shall determined from the Scheduled Occupancy Input SNVT.

b. Terminal Unit Occupancy Output: If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, the Terminal Unit Occupancy Output shall be determined by the default schedule. Otherwise, the output shall be determined as follows:

(1) If the Override Occupancy Input is not OC_NUL, the Terminal Unit Occupancy Output shall be determined from the Override Occupancy Input SNVT.:

(2) Otherwise, The Terminal Unit Occupancy Output shall determined from the Scheduled Occupancy SNVT.

3.4.1.4 Air Handler System Scheduling

a. The AHU Occupancy Output SNVT shall be bound from the System Scheduler to the DDC Hardware that executes the Occupancy Mode Determination part of the Air Handler Sequence of Operation

b. For Air Handlers using occupancy sensors, the output SNVT (of type SNVT_Occupancy) of each occupancy sensor shall be bound to a Space Occupancy Input of the System Scheduler.

c. The Terminal Unit Occupancy Output SNVT shall be bound from the System Scheduler to each AHU-Dependent Terminal Unit.

d. AHU-Dependent Terminal Units with occupancy sensors shall have the Effective Occupancy SNVT (of type SNVT_Occupancy) of each Terminal Unit bound to a Space Occupancy Input of the System Scheduler.

3.4.1.5 Stand-Alone Terminal Unit Scheduling

The Terminal Unit Occupancy Output shall be bound from the System Scheduler to the DDC Hardware that executes the Occupancy Mode Determination part of the Terminal Unit Sequence of Operation.

3.4.2 Sequences of Operation for Air Handling Units

3.4.2.1 All-Air Small Package Unitary System

Contractor shall install DDC hardware to perform this Sequence of

Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Fan ON-AUTO Switch

(1) ON: With the thermostat fan ON-AUTO switch in the ON position, the DDC Hardware shall start the fan and it shall run continuously.

(2) AUTO: With the thermostat fan ON-AUTO switch in the AUTO position, the DDC Hardware operates the fan according to HEAT-OFF-COOL(-EMERG HEAT) switch.

b. HEAT-OFF-COOL-EMERG HEAT Switch

(1) HEAT-COOL-EMERG HEAT: With the thermostat switch in the HEAT or COOL or EMERG HEAT positions, the DDC Hardware shall operate the package unit according to the Occupancy Mode.

(2) OFF: With the thermostat switch in the OFF position, the DDC Hardware shall de-energize the heating unit and cooling unit and emergency supplemental heat.

c. Occupancy Modes

(1) Occupied: The unit DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

(2) Unoccupied: The unit DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

d. Safeties: The unit shall run subject to the unit manufacturer's safeties.

e. Zone Temperature Control

(1) In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP-UNOCC) shall be at the configured setpoint (ZN-T-SP-UNOCC) as shown.

(3) The DDC Hardware shall cycle the fan, cooling unit, heating unit, and emergency supplemental heat, in accordance with the HEAT-COOL(-EMERG HEAT) switch setting, to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP).

3.4.2.2 Heating and Ventilating Unit (or Unit Ventilator)

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switches: Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

b. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes:

(1) Occupied: The Unit's DDC Hardware shall be in the Occupied Mode when the input from the System Scheduler (SYS-OCC) is occupied or when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied.

(2) Unoccupied: The Unit's DDC Hardware shall be in the Unoccupied Mode when the input from the System Scheduler (SYS-OCC) is unoccupied and when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied.

c. System Enable and Loop Enable

(1) Occupied mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Zone Temperature Control loop and Mixed Air Damper Control shall be enabled.

(2) Unoccupied mode: All control loops shall be disabled. When BLDG-T drops below BLDG-T-LL-SP (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Zone Temperature Control loop shall be enabled.

d. Proofs and Safeties

(1) The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs: Supply fan status (proof) (SF-S)

(3) Safeties:

(a) Heating Coil discharge air temperature low limit (freeze stat) (HTG-DA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. Zone Temperature Control

(1) When this loop is enabled, the DDC Hardware shall modulate the heating valve and outside air, relief, and return air dampers in sequence to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP). Sequencing shall be as shown: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the outside air, relief, and return air dampers shall modulate to maintain zone temperature at setpoint. During occupied mode, outside air damper minimum position (OA-D-MIN) shall be as shown. Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the heating valve shall modulate towards open to maintain zone temperature setpoint.

(2) When this loop is disabled, the heating valve shall be closed and the outside air damper and relief damper shall be closed and the return damper shall be open.

f. Mixed Air Damper Control: When this is enabled, the outside air and relief air dampers shall be open and the return air damper shall be closed. When this is disabled, the outside air and relief air dampers shall be closed and the return air damper shall be open.

3.4.2.3 Single Zone with Heating and DX Cooling Coils

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switch: Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

b. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or

WarmUp/CoolDown.

c. System Enable and Loop Enable:

(1) Occupied Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

(2) Unoccupied mode: While the building temperature (BLDG-T) is above the low limit setpoint(BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Heating Coil Temperature Control loop shall be enabled. The Outside Air Flow Control, Economizer Damper Control, and DX Cooling Coil Control loops shall be disabled.

(3) Warm Up / Cool Down Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Minimum Outside Air Flow Control loop shall be disabled. All other control loops shall be enabled.

d. Proofs and Safeties:

(1) The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs:
(a) Supply fan status (proof) (SF-S)

(3) Safeties:

(a) Heating coil discharge air temperature low limit (freeze stat) (HTG-DA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

f. Economizer Damper Control:

(1) When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers

(Economizer dampers) in sequence with the DX cooling coil control and heating coil control valve as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

(2) When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

(3) Economizer Enable Logic. The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C (2 degrees F) deadband.

g. Heating Coil Control: When this loop is enabled the DDC Hardware shall modulate the heating coil control valve in sequence with the DX staging control or cooling coil valve and economizer dampers as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. When this loop is disabled, the heating coil control valve shall be closed.

h. DX Cooling Coil Control: When this loop is enabled the DDC Hardware shall stage the DX Unit or modulate the cooling coil control valve in sequence with the heating coil valve and economizer dampers as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. When this loop is disabled, the DX unit shall be off or cooling coil control valve shall be closed.

3.4.2.4 Single Zone with Dual-Temperature Coil

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switch: Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

b. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or WarmUp/CoolDown.

c. System Enable and Loop Enable:

(1) Occupied Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

(2) Unoccupied mode: While the building temperature (BLDG-T) is above the building low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Dual Temperature Coil Temperature Control loop shall be enabled. The Minimum Outside Air Flow Control, and Economizer Damper Control loops shall be disabled.

(3) Warm Up / Cool Down Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops enabled.

d. Proofs and Safeties:

(1) The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs: Supply fan status (proof) (SF-S)

(3) Safeties:

(a) Dual Temperature coil discharge air temperature low limit (freeze stat) (DT-DA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

f. Economizer Damper Control:

(1) When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers (Economizer dampers) in sequence with the dual temperature coil to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

(2) When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and

relief air dampers shall be closed, and the return air damper shall be open.

(3) Economizer Enable Logic. The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C (2 degrees F) deadband.

g. Dual Temperature Coil Control:

(1) When this loop is enabled, the DDC Hardware shall select heating or cooling mode based on a pipe-mounted dual-temperature supply water sensor. A single sensor may be used for multiple instances of this sequence.

(2) The DDC Hardware shall modulate the coil control valve in sequence with the economizer dampers as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

(3) When this loop is disabled, the control valve shall be closed.

3.4.2.5 Single Zone with Heating and Cooling Coils and Return Air Bypass

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switch: Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

b. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or WarmUp/CoolDown.

c. System Enable and Loop Enable:

(1) Occupied Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

(2) Unoccupied mode: While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the

supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Heating Coil Temperature Control loop shall be enabled. All other control loops shall be disabled.

(3) Warm Up / Cool Down Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

d. Proofs and Safeties:

(1) The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs: Supply fan status (proof) (SF-S)

(3) Safeties:

(a) Heating coil discharge air temperature low limit (freezestat) (HTG-DA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

f. Economizer Damper Control:

(1) When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, return air, and relief air dampers (Economizer dampers) in sequence with the bypass and supply dampers and the heating coil control valve as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

(2) When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

(3) Economizer Enable Logic. The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall

each have a 1 degree C (2 degrees F) deadband.

g. Temperature Control LoopHeating Coil Control: When this loop is enabled the DDC Hardware shall modulate the heating coil control valve, modulate the economizer dampers if enabled, open and close the 2-position cooling coil valve and modulate the bypass and supply air dampers in sequence to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. When this loop is disabled both valves shall be closed and the bypass and supply air dampers shall be positioned to bypass air..

3.4.2.6 Single Zone with Humidity Control

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switch: Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

    (1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

    (2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

    (3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS)command and Safeties.

b. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or WarmUp/CoolDown.

c. System Enable and Loop Enable:

    (1) Occupied Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

    (2) Unoccupied mode: While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Preheat Coil Control loop and Reheat Coil Control loop shall be enabled and all other loops shall be disabled.

    (3) Warm Up / Cool Down Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

d. Proofs and Safeties

(1) The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs: Supply fan status (proof) (SF-S)

(3) Safeties:
(a) Preheat coil discharge air temperature low limit (freezestat) (PH-DA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

f. Preheat Coil Control Loop: When this loop is enabled the DDC Hardware shall modulate the preheat coil valve to maintain the preheat coil discharge air temperature (PH-DA-T) at setpoint (PH-DA-T-SP) as shown. When this loop is disabled, the preheat coil valve shall be closed.

g. Cooling-and-Dehumidification Coil Control: When this loop is enabled the DDC Hardware shall modulate the cooling and dehumidification valve to maintain either the zone temperature (ZN-T) at setpoint (ZN-T-SP) or zone relative humidity (ZN-RH) at setpoint (ZN-RH-SP), whichever calls for more chilled water flow. The valve shall be modulated in sequence with the reheat valve and humidification valve as shown to avoid simultaneous cooling and reheating, and simultaneous dehumidification and humidification. When this loop is disabled, the coil valve shall be closed.

h. Reheat Coil Control: When this loop is enabled the DDC Hardware shall modulate the reheat coil valve to maintain the zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. The valve shall be modulated in sequence with the cooling-and-dehumidification valve as shown to avoid simultaneous cooling and reheating. When this loop is disabled, the coil valve shall be closed.

i. Humidification Control: When this loop is enabled the DDC Hardware shall modulate the humidifier valve to maintain zone relative humidity (ZN-RH) at setpoint (ZN-RH-SP). The valve shall be modulated in sequence with the cooling-and-dehumidification valve as shown to avoid simultaneous dehumidification and humidification. When the supply air duct humidity (SA-RH) rises above 80% relative humidity, the humidifier valve shall begin to modulate towards closed and shall continue to gradually move towards closed until the supply air duct humidity reaches 90% relative humidity, at which point the humidifier valve shall be fully closed. When this loop is disabled, the humidifier valve shall be closed.

3.4.2.7 Multizone Dual-Duct with or without Return Fan

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switches and Fire Alarm Panel (FAP) signal:

Supply Fan VFD. Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS)command and Safeties.

b. Return Fan VFD. The return fan shall incorporate an integral H-O-A switch, manual speed adjustment and also accept a Fire Alarm Panel (FAP) signal. The return fan shall run according to the following inputs (in order of decreasing priority):

(1) FAP signal shall cause the RF to run at 100%

(2) SF-S (proof) shall be connected to the RF VFD safety circuit such that if SF is not running, RF shall be off.

(3) RF H-O-A switch shall select RF mode as follows:

(a) When switch is in Hand, fan shall run. Fan speed shall be under manual control.

(b)When switch is in Off, fan shall be off.

(c) When switch is in Auto, fan shall run. Fan speed shall be under control of the DDC Hardware.

c. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or WarmUp/CoolDown.

d. System Enable and Loop Enable:

(1) Occupied Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled.

The Zone Temperature Control loops serviced by the AHU shall also be enabled.

(2) Unoccupied mode: While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Hot Deck Coil Control loop and all Zone Temperature Control loops shall be enabled, and all other control loops shall be disabled.

(3) Warm Up / Cool Down Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

e. Proofs and Safeties:

(1) The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs:

(a) Supply fan status (proof) (SF-S)

(b)Return fan status (proof) (RF-S)

(3) Safeties:

(a) Mixed air temperature low limit (freeze stat) (MA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

f. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

g. Mixed Air Temperature Control With Economizer:

(1) When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature (MA-T) at setpoint (MA-T-SP) as

shown.

(2) When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

(3) Economizer Enable Logic. The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C (2 degrees F) deadband.

h. Hot Deck Coil Control:

(1) When this loop is enabled the DDC Hardware shall modulate the hot deck heating coil valve to maintain the hot deck temperature (HD-T) at setpoint (HD-T-SP) as shown. When this loop is disabled, the hot deck coil valve shall be closed.

(2) The DDC Hardware shall reset the hot deck temperature setpoint (HD-T-SP) using a linear reset schedule as shown. Reset of the setpoint (HD-T-SP) shall be based on Outside Air Temperature or Coldest Zone Temperature.

i. Cold Deck Coil Control: When this loop is enabled the DDC Hardware shall modulate the cold deck cooling coil valve to maintain the cold deck temperature (CD-T) at setpoint (CD-T-SP) as shown. When this loop is disabled, the cold deck cooling coil valve shall be closed.

j. Zone Temperature Control: When this loop is enabled:

(1) The zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) The DDC Hardware shall modulate the hot deck and cold deck dampers to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP).

3.4.2.8 Multizone with Hot Deck Bypass with or without Return Fan

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switches:
Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS)command and Safeties.

b. Return fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches shall start the fan. The return fan motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the return fan shall run subject to Safeties.

(2) OFF: With the H-O-A switch in OFF position, the return fan shall be off.

(3) AUTO: With the H-O-A switch in AUTO position, the return fan shall run subject to the supply fan running.

c. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or WarmUp/CoolDown.

d. System Enable and Loop Enable:

(1) Occupied Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

(2) Unoccupied mode: While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), and all Zone Temperature Control loops shall be enabled. The Minimum Outside Air Flow Control, Mixed Air Temperature Control With Economizer, and Cold Deck Coil Control loops shall be disabled.

(3) Warm Up / Cool Down Mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

e. Proofs and Safeties:

(1) The supply fan, return fan, and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs:

(a) Supply fan status (proof) (SF-S)

(b) Return fan status (proof) (RF-S)

(3) Safeties:

(a) Mixed air temperature low limit (freeze stat) (MA-T-LL)

(b) Supply air smoke (SA-SMK)

(c) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

f. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

g. Mixed Air Temperature Control With Economizer:

(1) When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature (MA-T) at setpoint (MA-T-SP) as shown.

(2) When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

(3) Economizer Enable Logic. The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C (2 degrees F) deadband.

h. Cold Deck Coil Control: When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the cold deck supply air temperature (SA-T) at setpoint (SA-T-SP) as shown. When this loop is disabled, the cooling coil valve shall be closed.

i. Zone Temperature Control:

(1) The zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) The DDC Hardware shall modulate the zone bypass and cold deck dampers, and the zone heating coil valve to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP). Sequencing shall be as shown: Upon a rise in zone temperature above zone temperature setpoint, subject to the zone temperature setpoint deadband as shown, the zone cold deck damper shall modulate towards open as

the bypass deck damper modulates towards closed. Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the bypass damper shall be full open and the zone heating valve shall modulate towards open.

(3) Systems with electric resistance heating elements shall require proof of air flow before activating the heating elements.

3.4.2.9 Variable Air Volume System with or without Return Fan

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. HAND-OFF-AUTO switches:
Supply fan variable frequency drive (VFD) unit shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other VFD inputs and switches and shall cause the VFD to run at 100% speed. The VFD shall accept an occupant accessible emergency shutoff switch as shown. The supply fan variable frequency drive (VFD) unit shall have an integral H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties. Fan speed shall be under manual-operator control.

(2) OFF: With the H-O-A switch in OFF position, the supply fan shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop Signal (SF-SS) and Safeties. Fan speed shall be under control of the DDC Hardware.

b. Return fan variable frequency drive (VFD) unit shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other VFD inputs and switches and shall cause the VFD to run at 100% speed. The return fan variable frequency drive (VFD) unit shall have an integral H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the return fan shall run subject to Safeties. Fan speed shall be under manual-operator control.

(2) OFF: With the H-O-A switch in OFF position, the return fan shall be off.

(3) AUTO: With the H-O-A switch in AUTO position, the return fan shall run subject to the supply fan running. Fan speed shall be under control of the DDC Hardware.

c. Occupancy Modes: The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied, or Warm Up/Cool Down.

d. Proofs and Safeties:

(1) The supply fan, return fan, and all DDC Hardware control loops

shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the VFD as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

(2) Proofs:
(a) Supply fan status (SF-S)

(b) Return fan status (RF-S)

(3) Safeties:
(a) Preheat coil discharge air temperature low limit (freezestat) (PH-DA-T-LL) for systems with a preheat coil. Cooling coil discharge air temperature low limit (freezestat) (CLG-DA-T-LL) for all other systems

(b) Supply air duct pressure high limit (SA-P-HL)

(c) Supply air smoke (SA-SMK)

(d) Return air smoke (RA-SMK)

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. System Enable and Loop Enable

(1) Occupied mode: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled.

(2) Unoccupied mode: While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C (5 degrees F) deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Supply Duct Static Pressure Control, Return Fan Volume Control, Preheat Control loops shall be enabled. The Minimum Outside Air Flow Control, Mixed Air Temperature Control, and Cooling Coil Control loops shall be disabled.

(3) Warm Up/Cool Down: The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

f. Fan Capacity Control:

(1) Supply Duct Static Pressure Control. When this loop is enabled the DDC Hardware shall modulate the supply fan variable frequency drive unit to maintain the duct static pressure (SA-P) at setpoint (SA-P-SP) as shown, as measured by the duct static pressure tap and sensor as shown. When this loop is disabled, the DDC Hardware capacity modulation output to the VFD shall be zero percent.

(2) Return Fan Volume Control. When this loop is enabled the DDC Hardware shall modulate the return fan variable frequency drive unit to maintain a constant volumetric airflow difference at setpoint (F-DIFF-SP) as shown, as measured by the airflow measurement arrays located in the supply and return ducts as shown. When this loop is disabled, the output to the VFD shall be zero percent.

g. Minimum Outside Air Flow Control: When this loop is enabled the DDC Hardware shall modulate the minimum outside air damper to maintain the minimum OA volumetric flow (MINOA-F) at setpoint (MINOA-F-SP) as shown. When this loop is disabled, the minimum outside air damper shall be closed.

h. Mixed Air Temperature Control With Economizer

(1) When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature (MA-T) at setpoint (MA-T-SP) as shown.

(2) When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

(3) Economizer Enable Logic. The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C (2 degrees F) deadband.

i. Cooling Coil Control: When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the supply air temperature (SA-T) setpoint (SA-T-SP) as shown. When this loop is disabled, the cooling coil valve shall be closed.

j. Preheat Coil Control: When this loop is enabled the DDC Hardware shall modulate the preheat coil valve to maintain the preheat coil discharge air temperature (PH-DA-T) at setpoint (PH-DA-T-SP) as shown. When this loop is disabled, the preheat coil valve shall be closed.

3.4.3 Sequences of Operation for Terminal Units

3.4.3.1 Zone Temperature Control - Cooling-Only VAV Box

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Occupancy Modes:

(1) Occupied: The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

(2) Unoccupied: The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

b. Safeties: This system has no safeties.

c. Zone Temperature Control

(1) In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown. The DDC Hardware shall modulate the VAV box damper to maintain VAV box supply air flow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Sequencing shall be as shown: Upon a rise in zone temperature (ZN-T) above zone setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum flow based on the difference between zone temperature and zone temperature setpoint as shown.

(2) In the Unoccupied Mode the VAV box damper shall be at its minimum position.

3.4.3.2 Zone Temperature Control - VAV Box with Reheat

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Occupancy Modes:

(1) Occupied: The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

(2) Unoccupied: The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

b. Safeties: VAV boxes with electric resistance heating elements shall require proof of air flow before activating the heating elements.

c. Zone Temperature Control:

(1) In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint as shown.

(3) The DDC Hardware shall modulate the VAV box damper to maintain VAV box supply air flow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box.

Sequencing shall be as shown: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum flow based on the difference between zone temperature and zone temperature setpoint as shown. Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the airflow shall be maintained at a fixed air flow setpoint (with a setting independent of the cooling minimum air flow), and the heating valve shall modulate towards open or the staged electric resistance heating coil(s) shall cycle on in sequence.

3.4.3.3 Zone Temperature Control - Fan Powered VAV Box

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Occupancy Modes:

(1) Occupied: The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

(2) Unoccupied: The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

b. Safeties: VAV boxes with electric resistance heating elements shall require proof of air flow before activating the heating elements.

c. Fan Control: Series fans shall run whenever the box is occupied or the Zone Temperature Control loop determines that the box is in heating mode. Prior to starting the fan, the supply damper shall close. The controller shall pause after closing the damper before starting the fan to ensure that the fan is not spinning due to supply air delivered by the AHU. After the fan starts, the supply damper shall be controlled by the Zone Temperature Control loop. Parallel fans shall run whenever the Zone Temperature Control loop determines that the box is in heating mode.

d. Zone Temperature Control:

(1) In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP)shall be at the configured setpoint as shown.

(3) Sequencing:

(a) Cooling Mode: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum based on the difference between zone temperature and zone temperature setpoint as shown. The DDC Hardware shall modulate the VAV box damper to mix supply and plenum return air as it maintains VAV box supply airflow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box.

(b) Heating Mode: Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the DDC Hardware shall first turn on the parallel fan and then modulate the VAV box damper to mix supply and plenum return air to maintain a fixed air flow setpoint (with a setting independent of the cooling minimum air flow), and the heating valve shall modulate towards open or the staged electric resistance heating coil(s) shall cycle on in sequence.

3.4.3.4 Perimeter Radiation Control Sequence

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Occupancy Modes

(1) Occupied: The radiator DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

(2) Unoccupied: The radiator DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

b. Safeties: This system has no safeties.

c. Space Temperature Control

(1) In the Occupied Mode the DDC Hardware shall modulate the heating control valve to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the DDC Hardware shall modulate the heating control valve to maintain space temperature at the configured setpoint as shown.

3.4.3.5 Unit Heater and Cabinet Unit Heater

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Off-Auto Switch

(1) OFF: With the thermostat OFF-AUTO switch in the OFF position, the DDC Hardware shall stop the fan and close the heating control valve.

(2) AUTO: With the thermostat OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the unit in accordance with its Occupancy Mode.

b. Occupancy Modes

(1) Occupied: The unit heater DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

(2) Unoccupied: The unit heater DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

c. Safeties: The unit shall run subject to the unit manufacturer's safeties.

d. Space Temperature Control

(1) In the Occupied Mode the DDC Hardware shall modulate the heating control valve and cycle the multi-speed fan to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the DDC Hardware shall modulate the heating control valve and cycle the multi-speed fan to maintain space temperature at the configured setpoint as shown.

3.4.3.6 Gas-Fired Infrared Heater

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. On-Off-Auto Switch

(1) ON: With the thermostat ON-OFF-AUTO switch in the ON position, the DDC Hardware shall energize the heater and the heater shall run continuously.

(2) OFF: With the thermostat ON-OFF-AUTO switch in the OFF position, the DDC Hardware shall de-energize the heater.

(3) AUTO: With the thermostat ON-OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the heater in accordance with its Occupancy Mode.

b. Occupancy Modes

(1) Occupied: The unit DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied.

(2) Unoccupied: The unit DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is

unoccupied.

c. Safeties: The heater shall run subject to the unit manufacturer's safeties.

d. Space Temperature Control

(1) In the Occupied Mode the DDC Hardware shall operate the heater to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the DDC Hardware shall operate the heater to maintain space setpoint at the configured unoccupied setpoint as shown.

3.4.3.7 Dual Temperature Fan-Coil Unit

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. Off-Auto Switch

(1) OFF: With the thermostat OFF-AUTO switch in the OFF position, the DDC Hardware shall stop the fan and close the dual-temperature control valve.

(2) AUTO: With the thermostat OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the unit in accordance with its Occupancy Mode.

b. Occupancy Modes

(1) Occupied: The unit DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

(2) Unoccupied: The unit DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

c. Heat/Cool Modes: The DDC Hardware shall automatically switch the fan coil unit DDC Hardware between the heating and cooling modes and the resultant control action, based on a pipe-mounted dual-temperature supply water temperature sensor.

d. Safeties: The unit shall run subject to the unit manufacturer's safeties.

e. Space Temperature Control

(1) In the Occupied Mode the DDC Hardware shall modulate the dual-temperature control valve and modulate the multi-speed fan to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

(2) In the Unoccupied Mode the DDC Hardware shall modulate the dual-temperature control valve and modulate the multi-speed fan to maintain space temperature at the configured setpoint as shown.

3.4.4 Sequences of Operation for Hydronic Systems

3.4.4.1 Hydronic Heating Hot Water from Distributed Steam or HTHW Converter

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. System Enable and loop enable

(1) This system shall monitor the enabled status of all systems served by this system. If one, two or more systems served by this system are enabled, this system shall be enabled (SYS-ENA), otherwise this system shall be disabled.

(2) When this system is enabled (SYS-ENA) the hot water pump shall be commanded on via the Hot Water Pump Start/Stop (HW-PMP-SS) command.

(3) When this system is enabled (SYS-ENA) and the hot water pump is proofed on, the Heat Exchanger Control loop shall be enabled.

b. HAND-OFF-AUTO Switch: The hot water pump motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the pump shall start and run continuously.

(2) OFF: With the H-O-A switch in OFF position, the pump shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command.

c. Proofs and Safeties:

(1) DDC Hardware shall monitor all proofs and safeties.

(2) Proofs: Hot water pump status (HW-PMP-S)

(3) Safeties: None

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

d. Heat Exchanger Valve Control: When this loop is enabled DDC Hardware shall modulate the steam or high temperature hot water valve to maintain the Hot Water Supply Temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HW-T-SP) shall be determined from a linear reset schedule as shown. When this loop is disabled, the valve shall be closed.

3.4.4.2 Hydronic Heating Hot Water From Single-Building Boiler

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. System Enable and loop enable

(1) This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If no systems served by this system are enabled, this system shall be disabled

(2) When this system is enabled (SYS-ENA) and the hot water pump is proofed on, the boiler control and hot water temperature control loops shall be enabled.

b. HAND-OFF-AUTO Switch: The hot water pump motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the pump shall start and run continuously.

(2) OFF: With the H-O-A switch in OFF position, the pump shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command.

c. Proofs and Safeties:

(1) DDC Hardware shall monitor all proofs and safeties.

(2) Proofs: Hot water pump

(3) Safeties: None

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

d. Boiler Control: When this loop is enabled, the DDC Hardware shall turn the boiler on. When this loop is disabled, the boiler shall be off.

e. Hot Water Temperature Control: When this loop is enabled the DDC Hardware shall modulate the 3-way mixing valve to maintain hot water supply temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HWS-T-SP) shall be determined from a linear reset schedule as shown. When this loop is disabled, the valve shall be in its normal (failsafe) position.

3.4.4.3 Hydronic Dual-Temperature System with Steam or High Temperature Hot Water Heat Exchanger and Chilled Water

Install DDC hardware to perform this Sequence of Operation and to provide

SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. System Enable and loop enable

(1) This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If all systems served by this system are not enabled, this system shall not be enabled.

(2) When the system is enabled (SYS-ENA) the pump shall run.

(3) When this system is enabled (SYS-ENA), and the HEATING/COOLING switch is in HEATING the Heat Exchanger Control loop shall be enabled.

(4) When this system is enabled (SYS-ENA), and the HEATING/COOLING switch is in COOLING and the dual-temperature return water (DTWR-T) is below the dual-temperature return water high-limit temperature (DTWR-T-HL) setpoint of 29 degrees C (85 degrees F), the chiller shall be enabled.

b. Switchover valve operation

(1) With the HEATING/COOLING switch in the HEATING position, the switchover valve shall open the heat-cool system piping to the heat exchanger and close the heat-cool system piping to the central plant chilled water or single-building chiller.

(2) With the HEATING/COOLING switch in the COOLING position, the switchover valve shall open the heat-cool system piping to the central plant chilled water or single-building chiller and close the heat-cool system piping to the heat exchanger whenever the dual-temperature return water temperature (DTWR-T) is below the dual-temperature return water high-limit temperature (DTWR-T-HL).

(3) The DDC Hardware shall monitor the status of the DTWR-T-LL and DTWR-T-HL switches.

c. HAND-OFF-AUTO Switch: The Dual-Temperature water pump motor starter shall have an H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the pump shall start and run continuously.

(2) OFF: With the H-O-A switch in OFF position, the pump shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the pump shall run subject to the Dual-Temperature Water Pump Start/Stop (DTW-PMP-SS) System Enable (SYS-ENA) command.

d. Proofs and Safeties

(1) DDC Hardware shall monitor all proofs and safeties.

(2) Proofs: None

(3) Safeties: Heat exchanger differential pressure switch (HX-P-LL) shall be direct-hardwire interlocked to the steam or high temperature hot water valve.

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

e. Heat Exchanger Mixing Valve Control: When this loop is enabled the DDC Hardware shall modulate the steam or high temperature hot water valve to maintain the Hot Water Supply Temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HWS-T-SP) shall be determined from a linear reset schedule as shown. The DDC Hardware shall monitor the status of the HX-P-LL safety. When this loop is disabled, the valve shall be closed.

3.4.4.4 Hydronic Secondary with Variable Speed Pump

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

a. System Enable and loop enable:

(1) This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If all systems served by this system are not enabled, this system shall not be enabled.

(2) When this system is enabled (SYS-ENA) the Pressure Control loop shall be enabled.

b. HAND-OFF-AUTO Switch: The hot water pump variable frequency drive (VFD) unit shall have an integral H-O-A switch:

(1) HAND: With the H-O-A switch in HAND position, the pump shall start and run continuously. Pump speed shall be under manual-operator control.

(2) OFF: With the H-O-A switch in OFF position, the pump shall stop.

(3) AUTO: With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command and pump speed shall be under control of the DDC system.

c. Proofs and Safeties

(1) DDC Hardware shall monitor all proofs and safeties.

(2) Proofs: None

(3) Safeties: None

(4) DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

d. Pressure Control: When this loop is enabled the DDC Hardware shall modulate the pump variable frequency drive unit to maintain the pipe system pressure at setpoint as shown, as measured by the differential pressure tap and sensor as shown. When this loop is disabled, the DDC Hardware capacity modulation output to the VFD shall be zero percent.

3.5 CONTROLLER TUNING

Tune each controller in a manner consistent with that described in the ASHRAE FUN SI (ASHRAE FUN IP). Tuning shall consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop shall be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable shall settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output shall be steady. With the exception of naturally slow processes such as zone temperature control, the controller shall settle out at the new setpoint within five (5) minutes. Set the controller to its correct setpoint and record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.6 START-UP AND START-UP TEST

Perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

a. General: Adjust, calibrate, measure, program, configure, set the time schedules, and otherwise perform all necessary actions to ensure that the systems function as specified and shown in the sequence of operation and other contract documents.

b. Systems Check: An item-by-item check shall be performed for each HVAC system;

(1) Step 1 - System Inspection: With the system in unoccupied mode and with fan hand-off-auto switches in the OFF position, it shall be verified that power and main air are available where required and that all output devices are in their failsafe and normal positions. Each local display panel and each M&C Client shall be inspected to verify that all displays indicate shutdown conditions.

(2) Step 2 - Calibration Accuracy Check: A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the value from the test instrument to the corresponding SNVT. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensor

accuracy. The calibration of the test instruments shall be traceable to National Institute of Standards and Technology standards. The first check point shall be with the HVAC system in unoccupied mode with fan hand-off-auto switches in the OFF position, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

(3) Step 3 - Actuator Range Check: With the system running, a signal shall be applied to each actuator through the DDC Hardware controller. Proper operation of the actuators and positioners for all actuated devices shall be verified and the signal levels shall be recorded for the extreme positions of each device. The signal shall be varied over its full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, it shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

c. Weather Dependent Test: Weather dependent test procedures shall be performed in the appropriate climatic season.

3.6.1 Start-Up and Start-Up Testing Report

Submit one hard copy & one digital copy (.pdf - text searchable) of the Start-Up and Start-Up Testing Report. The report may be submitted as a Technical Data Package documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.6.2 Draft LNS Database

Upon completion of the Start-Up Test, submit the Draft LNS Database reflecting the system as installed and configured at the completion of the Start-Up and Start-Up-Testing. Submit one hard copy & one digital copy (.pdf - text searchable) of the fully commissioned, draft LNS Database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Each copy shall be on CD-ROM and shall be clearly marked identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification. The submitted LNS Database shall consist of the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}.

3.7 PERFORMANCE VERIFICATION TEST (PVT)

3.7.1 PVT Procedures

Prepare PVT Procedures based on Section 25 08 10 Utility Monitoring and Control System Testing explaining step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. Submit one hard copy & one digital copy (.pdf - text searchable) of the PVT Procedures. The PVT Procedures shall be submitted as a Technical Data Package.

3.7.1.1 Sensor Accuracy Checks

The PVT shall include a one-point accuracy check of each sensor. The PVT shall include inlet and outlet air temperature measurements for all AHU-dependent terminal units.

3.7.1.2 Temporary User Interface

A temporary user interface shall be installed for the duration of the PVT to provide user display of SNVTs and the ability to override SNVTs as shown on the Points Schedule.

3.7.1.3 Endurance Test

The PVT shall include a one-week endurance test during which the system is operated continuously.

a. Install a device at each BPOC location and configure the device to poll all points shown on the Points Schedule as available to the Utility Monitoring and Control System throughout the endurance test.

   (1) All points on the Points Schedule with an alarm condition shall be polled at 5 minute intervals.

   (2) All points on the Points Schedule required for trending, overrides or graphical displays shall be polled at 15 minute intervals.

b. The PVT Procedure shall describe a methodology to measure and trend the network bandwidth usage on all Building Control Network channels, including the backbone, during the endurance test to demonstrate that bandwidth usage is less than 70% on all channels.

3.7.1.4 Network Peak Bandwidth Test

The PVT shall include a test demonstrating that the building control network is capable of supporting poll requests for all points indicated on the Points Schedules as available to the UMCS within a 2 minute interval using the same methodology as the endurance test bandwidth testing.

3.7.1.5 PVT Equipment List

A control system performance verification test equipment list shall be included in the PVT Procedures that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

3.7.2 PVT Execution

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, an LNS Network Configuration Tool software capable of reading and writing an LNS Database, and the approved Draft LNS Database, demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall measure and trend the

Network Bandwidth Usage and compare it to the Bandwidth Usage Calculation submittal. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the PVT Plan and Draft As-Builts and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems. If the system experiences any failures during the endurance test portion of the PVT the system shall be repaired and the endurance test portion of the PVT shall be repeated until the system operates continuously and without failure for the specified endurance test period.

3.7.3 PVT Report

Submit one hard copy & one digital copy (.pdf - text searchable) of the PVT Report. The PVT Report may be submitted as a Technical Data Package documenting all tests performed during the PVT and their results. Failures and repairs shall be documented with test results.

3.7.4 Final LNS Database

Submit a Final LNS Database which shall be the complete, final, commissioned as-built database for the system.

3.8 MAINTENANCE AND SERVICE

Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

The integration of the system specified in this section into a Utility Monitoring and Control System including the re-addressing of devices on the network, shall not, of itself, alter the requirement for the one year maintenance and service period.

The changing of device configuration properties or the binding of network variables for supervisory control shall not, of itself, alter the requirement for the one year maintenance and service period.

All work performed after the submission of the final as-built LNS Database shall be performed using a Government furnished LNS database, which may not be identical to the submitted as-built database due to changes in binding, configuration properties or device addressing as a result of system integration. Unless otherwise approved, do not use any other database to perform work on the system.

3.8.1 Description of Work

The adjustment and repair of the system shall include the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

3.8.2 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

3.8.3 Scheduled Inspections

Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in June and December. These inspections shall include:

a. Visual checks and operational tests of equipment.

b. Clean control system equipment including interior and exterior surfaces.

c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all digital inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital inputs and outputs during the second inspection.

d. Run system software diagnostics and correct diagnosed problems.

e. Resolve any previous outstanding problems.

3.8.4 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding Federal holidays.

3.8.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 24 hours after receiving a request for service. The control system shall be restored to proper operating condition as required per Section 01 78 00 CLOSEOUT SUBMITTALS.

3.8.6 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

3.8.7 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

3.8.8 Work Requests

Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

3.8.9 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions and other documentation affected, and an updated copy of the LNS Database used to make the modifications shall be provided..

3.9 TRAINING

A training course shall be conducted for operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. 32 hours of training shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site and the Government reserves the right to make audio and visual recordings of the training sessions for later use. Audiovisual equipment and 2 sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.9.1 Training Documentation

Prepare training documentation consisting of:

a. Course Attendee List: A List of course attendees which shall be developed in coordination with and signed by the Controls, HVAC, Electrical shop supervisor.

b. Training Manuals: Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals. Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site. Training manuals shall be delivered for each trainee on the Course Attendee List with one hard copy & one digital copy (.pdf - text searchable) delivered for archival at the project site. copies of the Course Attendee List shall be delivered with the archival copies. The Training Documentation may be submitted as a Technical Data Package.

3.9.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, repair procedures, use of LNS Plug-ins, use of AGC Programming software, and use of the GPPC Programming software. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the Start-Up and Start-Up Testing Report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

APPENDIX A

QC CHECKLIST

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

This checklist is for (check one:)

Pre-Construction QC Checklist Submittal	(Items 1-5)	|____|
Post-Construction QC Checklist Submittal	(Items 1-12)	|____|
Close-out QC Checklist Submittal	(Items 1-19)	|____|

Initial and date each item in the spaces provided verifying that each requirement has been met.

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklists Submittal:

1	All DDC Hardware (nodes) are numbered on Control System Schematic Drawings.	___	______
2	Signal lines on Control System Schematic are labeled with the signal type.	___	______
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	___	______
4	Points Schedule drawings have been sub-divided by device (DDC Hardware), including DDC Hardware node numbers.	___	______

Items verified for Post-Construction and Closeout QC Checklist Submittal:

5	All DDC Hardware is installed on a TP/FT-10 local control bus.	___	______
6	All Application Specific Controllers (ASCs) are LonMark certified.	___	______
7	Communication between DDC Hardware is only via CEA-709.1-D using SNVTs. Other protocols and network variables other than SNVTs have not been used.	___	______
8	Explicit messaging has not been used.	___	______
9	System Scheduler functionality has been installed for all HVAC systems and default schedules have been configured at each System Scheduler.	___	______
10	All sequences are performed as specified using DDC Hardware.	___	______
11	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	___	______

QC CHECKLIST

Items verified for Closeout QC Checklists Submittal:

12	Final As-built Drawings, including the Points Schedule drawings, accurately represent the final installed system.	|___|______|
13	LonWorks Network Services (LNS) Database is up-to-date and accurately represents the final installed system.	|___|______|
14	LNS Plug-ins have been submitted for all ASCs.	|___|______|
15	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs) and all Application Generic Controllers (AGCs).	|___|______|
16	All software has been licensed to the Government	|___|______|
17	O&M Instructions have been completed and submitted.	|___|______|
18	Training course has been completed.	|___|______|

____

(QC Representative Signature) (Date)

-- End of Section --

SECTION 23 09 53.00 20

SPACE TEMPERATURE CONTROL SYSTEMS
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE FUN IP	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, SI Edition

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASME BPVC	(2010) Boiler and Pressure Vessels Code

ASTM INTERNATIONAL (ASTM)

ASTM A126	(2004; R 2014) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2013) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ST 1	(1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 508	(1999; Reprint Oct 2013) Industrial Control Equipment
UL 555S	(2014) Smoke Dampers
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment

1.2 SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph entitled "Subcontractor Special Requirements" in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS. The paragraph specifies that all contract requirements of this section shall be accomplished directly by a first tier subcontractor. No work required shall be accomplished by a second tier subcontractor.

1.3 SYSTEM DESCRIPTION

Provide new and modify existing space temperature control systems complete and ready for operation.

1.4 SYSTEM REQUIREMENTS

Provide control systems composed of any combination of electric, analog electronic or pneumatic devices. Indicated control system devices of a particular type do not intend a requirement for the device unless the requirement is specifically indicated. Requirements apply to field installed control systems.

Provide new equipment compatible with the existing control system to the extent that the direct interface uses the same control signal type and level over the same calibrated range as the existing equipment.

Inspect and test reused portions of existing control systems, and furnish a report to the Government identifying all inoperative components or system deficiencies. The report shall include a cost estimate to correct deficiencies, scheduled need dates for equipment shutdown for repairs and connection to existing controls and systems. Proceed with repairs only after receipt of Government approval. Diagnose and report any malfunctions of existing control system device that occurs after the work commences. The Government is responsible for maintenance and repair of Government equipment. The Contractor shall be held responsible for repair costs due to Contractor negligence or abuse of Government equipment.

1.5 PERFORMANCE REQUIREMENTS

Provide control systems to maintain the required heating, ventilating, and cooling (HVAC) conditions by performing the functions and sequences of operations indicated. Control systems shall be complete, including all equipment and appurtenances, and ready for operation. Control systems shall be furnished, installed, tested, calibrated, and started up by, or under the supervision of trained technicians certified by the Contractor as qualified and regularly employed in such work. Control system equipment, valves, panels and dampers shall bear the manufacturer's nameplate.

1.6 DESIGN REQUIREMENTS

1.6.1 Control System Diagrams

For each system, indicate HVAC process flow and location of devices relative to flow and to the HVAC control panel, the connections of control devices in control loops, references of control device contacts and device operating coils to line numbers of a ladder diagram and sequencing diagrams showing the operation of valves, dampers, and contacts relative to controller output, and HVAC process variables.

1.6.2 Ladder Diagram

Indicate connections and interlocks to control system devices and other devices such as starters, drives, HVAC control system panels, and HVAC equipment panels. Diagram shall be coordinated by line number and device number with each control system diagram.

1.6.3 Operating Parameters

Indicate operating parameters for devices shown on the control system diagram such as setpoints, ranges, limits, differentials, outside air temperature schedules, contact operating points, and HVAC equipment operating time schedules.

1.6.4 Automatic Control Valve Schedules

Indicate valve size, Cv, flow rate, pressure drop, top size, spring range, positioner range, operating signal characteristics, and power source.

1.6.5 Damper Schedules

Indicate damper sizes, quantities and sizes of actuators, spring ranges, positioner ranges, operating signal characteristics, and power source.

1.6.6 Wiring Diagram

Indicate terminal blocks, wire marker identification, connections to control system devices, external and internal power sources, and connections to external devices, starters, drives, control panels, jumpers, and ground connections.

1.6.7 Compressed Air Station Schematic

Indicate compressors, motors and horsepower rating, voltage, starter, isolators, manual bypasses, tubing sizes, drain piping and drain traps, reducing valves, dryer, manufacturers' names and model numbers, mounting, access, and clearance requirements. Also include control panel schematics for pneumatic control.

1.6.8 Sequence of Operation

Sequence of operation for each HVAC control system coordinated with device identifiers on control system diagram and ladder diagram.

1.6.9 Arrangement Drawing

Arrangement diagram of each HVAC control system panel coordinated with device identifiers on the control system diagram and the ladder diagram.

1.7 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Control system diagrams for each HVAC system; G

Ladder diagram; G

Operating parameters; G

Automatic control valve schedules; G

Damper schedules; G

Sequence of operation; G

Arrangement drawing; G

Wiring diagram; G

Compressed air station schematic; G

Control panel schematics for pneumatic control; G

SD-03 Product Data

Actuators; G

Valves; G

Dampers; G

Fire protection devices; G

Sensors; G

Thermostats; G

Sunshields; G

Pressure switches; G

Indicating devices; G

Controllers; G

Pressure gages; G

Control panels; G

Air Compressor; G

Refrigerated air dryer; G

Air filtration system; G

Compressed air station specialties; G

VAV Terminal unit controls; G

SD-06 Test Reports

Commissioning procedures; G

Calibration adjustment and commissioning reports; G

Site testing procedures identifying each item tested and describing each test; G

Performance verification test plans and procedures; G

SD-07 Certificates

Certification of completion

SD-08 Manufacturer's Instructions

Training course documentation

SD-10 Operation and Maintenance Data

Space temperature control system, Data Package 3; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Qualified service organization list

1.8 QUALITY ASSURANCE

1.8.1 Standard Products

a. Material and equipment shall be standard products of manufacturers regularly engaged in the manufacturing of such products, using similar materials, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of similarly sized equipment and materials used under similar circumstances.

The 2 years experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

b. The equipment items shall be supported by a service organization.

1.8.2 Nameplates and Tags

a. Provide nameplates bearing legends as shown and tags bearing device unique identifiers as shown shall have engraved or stamped characters. Nameplates shall be mechanically attached to HVAC control panel doors.

b. A plastic or metal tag shall be mechanically attached directly to each field-mounted device or attached by a metal chain or wire.

c. Each airflow measurement station shall have a tag showing flow rate range for signal output range, duct size, and device identifier where shown.

1.8.3 Verification of Dimensions

Contractor shall become familiar with details of work, shall verify dimensions in the field, and shall advise Contracting Officer of any discrepancy before performing work.

1.8.4 Modification of References

Accomplish work in accordance with ASME B31.1, ASME B31.5, NFPA 70, and NFPA 90A, except as modified herein or indicated otherwise for equipment, materials, installation, examination, inspection, and testing. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" had be substituted for the words "should" or "could" or "may," wherever they appear. Interpret reference to "authority having jurisdiction" and "owner" to mean the Contracting Officer.

1.8.5 Site Testing Procedures

Indicate test equipment to be used including manufacturers' names and model numbers, date of last calibration, and accuracy of calibration.

1.8.6 Commissioning Procedures

Define procedures specific to each control system including instructions on how to set control parameters and setpoints, proportional, integral and derivative mode constants, contact output settings, positioner range adjustments, and calibration checks of transmitters

1.8.7 Calibration Adjustment and Commissioning Reports

Submit specific to each HVAC control system, including settings adjustments and results of calibration checks

1.8.8 Space Temperature Control System

In addition to the requirements specified in the paragraph entitled "SUBMITTALS", meet the following requirements. Submit Operation and Maintenance Manuals for items of equipment listed under paragraph entitled "Product Data." Manual shall contain full hardware support documentation, which shall include but not be limited to the following:

a. General description and specifications

b. Installation and initial checkout procedures

c. Detailed electrical and logical description

d. Troubleshooting procedures, diagrams, and guidelines

e. Alignment and calibration procedures for components

f. Preventive maintenance requirements and a maintenance checklist

g. Detailed schematics and assembly drawings

h. Spare parts list data, including required tool kits and suggested method of repairs such as field repair, factory repair, or item replacement

i. Signal identification and timing diagrams

j. Complete as-built control drawings, schedules, and sequence of operation

k. Controller configuration and parameter setting procedures

l. Step-by-step procedures required for each HVAC control systems startup, operation, shutdown, recovery, and fault diagnosis

m. Manufacturer supplied operator manuals for equipment

n. Qualified service organization list

PART 2 PRODUCTS

2.1 COMPONENTS

Provide components factory ordered for this project. Rebuilt equipment, warehoused equipment, or earlier generation equipment shall not be acceptable. Electrical, electronic, and electropneumatic devices not located within control panels shall have a NEMA 250 Type 1 enclosure in accordance with NEMA 250 unless otherwise specified. Actuators and positive positioners, and transmitters shall operate within temperature limit ratings of plus 2 to 66 degrees C (35 to 150 degrees F). Panel mounted instruments shall operate within limit ratings of 2 to 49 degrees C (35 to 120 degrees F) and 10 percent to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 2 to 66 degrees C (35 to 150 degrees F).

2.2 ACTUATORS

Provide pneumatic, electric, or electronic actuators. Actuators shall function as required within 85 to 110 percent of their power supply rating. Actuators shall fail to their spring return positions on signal or power failure unless indicated as timed, power return actuators. Actuators shall have visible position indicators. Where actuators do not have positive spring returns for fail-safe operation, provide capacity tanks, restrictors, check valves, and relays, or reserve power as required to achieve proper timed positioning for up to 4 minutes after primary power failure. Actuators shall open or close the devices to which they are applied within 60 seconds after a full scale signal input change. Pneumatic actuators shall be rated for 172 kPa (gage) (25 psig) operating pressure except for high pressure cylinder type actuators.

2.2.1 Damper Actuators

Damper actuators shall be rated for at least 125 percent of the motive power necessary to operate the connected damper. The actuator stroke shall be limited by an adjustable stop in the direction of the return stroke. Actuators shall be provided with mounting and connecting hardware.

2.2.2 Valve Actuators

Valve actuators shall be rated for at least 125 percent of the motive power necessary to operate the valves over their full range of operation against the total and differential pressures.

2.2.3 Positive Positioners

Positive positioners shall be pneumatic relays with mechanical feedback mechanisms, adjustable operating ranges, and starting points.

2.3 AUTOMATIC CONTROL VALVES

Provide automatic control valves.

2.3.1 Valve Assembly

Valves shall have stainless steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall be designed for not less than 862 kPa (gage) (125 psig) working pressure or 150 percent of the system operating pressure, whichever is greater. Maximum rated shutoff pressure of the valve shall exceed the rated deadhead pressure of the pump that supplies it. Valve leakage rating shall be 0.01 percent of rated Cv for soft-seated valves and 0.05 percent for metal-to-metal seated valves. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall conform to ASME B16.5 as a minimum. Components of cast iron valves shall conform to ASTM A126 Class B or C as a minimum.

2.3.2 Butterfly Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service, and for modulation to the fully closed position, with carbon steel bodies or cast iron Class 125 and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from minus 29 degrees to plus 121 degrees C. (20 degrees to plus 250 degrees F.) Valves shall have a manual means of operation independent of the actuator.

2.3.3 Two-Way Valves

Two-way modulating valves shall have equal percentage characteristics.

2.3.4 Three-Way Valves

Three-way valves shall provide constant total flow throughout full plug travel.

2.3.5 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be provided for each flare-type end valve.

2.3.6 Valves for Chilled Water, Condenser Water, and Glycol Service

ASME B16.1. Bodies for valves 50 mm (2 inches) and smaller shall be brass or bronze, with threaded-end or union-end connections. Bodies for valves from 65 mm (2.5 inches) and larger shall be cast iron. Bodies for valves 65 mm (2.5 inches) and larger shall have flanged-end connections. Internal valve trim shall be brass or bronze except that valve stems may be Type 316 stainless steel. Water valves shall be sized for a 21 kPa (3 psi) differential through the valve at rated flow, except as indicated otherwise. Select valve flow coefficient (Cv) for an actual pressure drop not less than 50 percent or greater than 125 percent of the design pressure drop at design flow. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.3.7 Valves for Hot Water Service

Valves for hot water service below 121 degrees C (250 Degrees F) shall conform to ASME B16.1. Bodies for valves 50 mm (2 inches) and smaller shall be brass or bronze, with threaded-end or union-end connections. Bodies for valves 65 mm (2.5 inches) and larger shall be cast iron. Bodies for 65 mm (2.5 inches) and larger shall have flanged-end connections. Water valves shall be sized for a 21 kPa (3 psi) differential through the valve at rated flow, except as indicated otherwise. Select valve flow coefficient (Cv) for an actual pressure drop not less than 50 percent or greater than 125 percent of the design pressure drop at design flow. Internal trim, including seats, seat rings, modulating plugs, and springs, of valves controlling water hotter than 99 degrees C (210 degrees F) shall be Type 316 stainless steel. Internal trim for valves controlling water 99 degrees C (210 degrees F) or less shall be brass or bronze. Non-metallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of 121 degrees C or 10 degrees C (250 degrees F or 50 degrees F) above the system design temperature, whichever is higher. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.3.8 Valves for Steam Service

ASME B16.1. Bodies for valves 40 mm (1.5 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves 50 to 80 mm (2 to 3 inches) inclusive shall be brass, bronze, or cast iron. Bodies for valves 100 mm (4 inches) and larger shall be cast iron. Bodies for 50 mm (2 inch) valves shall have threaded ends. Bodies for valves 65 mm (2.5 inches) and larger shall be provided with flanged-end connections.

Internal valve trim shall be Type 316 stainless steel. Steam valves shall be sized for 103 kPa (gage) (15 psig) inlet steam pressure with a maximum 90 kPa (13 psi) differential through the valve at rated flow, except as indicated otherwise.

2.3.9 Valves for High Temperature Hot Water Service

Valves for high temperature hot water service above 121 degrees C (250 degrees F). Valve bodies shall conform to ASME B16.34 Class 300. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves 25 mm (one inch) and larger. Valves smaller than 25 mm (one inch) shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE). Internal valve trim shall be Type 316 stainless steel. Water valves shall be sized for a 21 kPa (3 psi) differential pressure through the valve at rated flow, except as indicated otherwise. Select valve flow coefficient (Cv) for an actual pressure drop not less than 50 percent or greater than 125 percent of the design pressure drop at design flow.

2.3.10 Valves for Compressed Air Service

Valves used for switching compressed air supplied to pneumatic systems shall be brass body, three-way valves which shall conform to ASME B16.15 Class 250.

2.4 DAMPERS

Provide dampers in air ducts.

2.4.1 Damper Assembly

Damper shall conform to SMACNA 1966. A single damper section shall have blades no longer than 1219 mm (48 inches) and shall be no higher than 1829 mm (72 inches). Maximum damper blade width shall be 200 mm (8 inches). Larger sizes shall consist of a combination of sections. Dampers shall be steel or other materials where indicated. Flat blades shall be made rigid by folding the edges. Provide blades with compressible seals at points of contact. Provide channel frames of dampers with jamb seals to minimize air leakage. Dampers shall not leak in excess of 51 L/s per square meter (10 cfm per square foot) at 996 Pa (4 inches water gage) static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 degrees C to 93 degrees C (40 degrees F to 200 degrees F). Dampers shall be rated at not less than 10 m/s (2000 fpm) air velocity. Moving parts of the operating linkage in contact with each other shall consist of dissimilar materials. Damper axles shall be 13 mm (0.5 inch) minimum plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by a non-ferrous dissimilar thrust bearings. Pressure drop through dampers shall not exceed 12 Pa (0.05 inch water) gage at 5 m/s (1,000 fpm) in the wide-open position. Frames shall not be less than 51 mm (2 inches) wide. Dampers shall be tested in accordance with AMCA 500-D.

2.4.2 Operating Links

Operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Mating parts shall consist of dissimilar materials. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crank arms shall control the open and closed position of dampers.

2.5 FIRE PROTECTION DEVICES

Provide smoke detectors in return and supply air ducts on the downstream side of the filters in accordance with NFPA 90A, except as otherwise indicated. Provide UL listed or FM approved detectors for duct installation.

2.5.1 Smoke Detectors

Provide in each air-handling system with supply air capacity greater than 944 L/s 2000 cfm in accordance with NFPA 90A. Locate downstream of the supply air filters and prior to any branch connection in accordance with NFPA 72.

Provide in each air-handling system, serving more than one story, and having a return air capacity greater than 7079 L/s 15000 cfm in accordance with NFPA 90A. Locate at each story prior to connection to common return and at return connection to air handler prior to any fresh air inlet connection and prior to any recirculation connection in accordance with NFPA 72. Design for detection of abnormal smoke densities by the ionization or photoelectric principle, responsive to both invisible and visible particles of combustion, and not susceptible to undesired operation by changes to relative humidity.

Provide UL listed or FM approved detectors for duct installation. Provide duct detectors with an approved duct housing, mounted exterior to the duct, and with perforated sampling tubes extending across the width of the duct. Provide permanent descriptive zone labels indicating in which air-handling units the detectors in alarm are located.

Provide detectors with a test port , test switch or remote keyed test device. Provide control and power modules required for operation of detectors in their own control unit or integral with the main building fire alarm control panel. A ground fault or single break or open condition in electrical circuitry to any detector or its control or power units shall cause activation of building fire alarm control panel trouble signals.

Electrical supervision of wiring used exclusively for air-handling unit shutdown is not required provided a break in wiring would cause shutdown of the associated unit. Equipment and devices shall be compatible and operable in all respects with, and shall in no way impair reliability or operational functions of, the existing building fire alarm system.

Smoke control and exhaust systems shall have provisions for automatic and manual operation by means of a key-operated switch to override any other shutdown features and shall be located adjacent to the fire alarm system control panel or as indicated.

2.5.2 Smoke Dampers and Combination Smoke/Fire Dampers

Smoke dampers and actuator assemblies as required in accordance with NFPA 90A shall meet the Class II leakage requirements of UL 555S. Dampers shall be factory fabricated, galvanized steel or stainless steel with lubricated bearings, linkages, and seals to withstand temperatures from minus 29 to 121 degrees C (20 to 250 degrees F). Provide replaceable seals. Combination smoke/fire dampers shall have a UL 1.5 hour rating and shall be equipped with electric/thermal links which close the damper at 74 degrees C (165 degrees F) and then automatically reset after normal temperature is restored by cycling damper actuator. Equip dampers with pneumatic or electric actuators which close smoke dampers tightly when activated. After the smoke has cleared, the dampers shall automatically reset.

2.6 SENSORS

2.6.1 Spans and Ranges

Transmitters shall be calibrated to provide an electric or electronic output signal of 4 to 20 mA electric or electronic and 21 to 103 kPa (3 to 15 psi) output for pneumatics over the indicated span or range.

a. Conditioned space temperature, from 10 to 38 degrees C (50 to 100 degrees F).

b. Duct temperature, from 4 to 60 degrees C (40 to 140 degrees F).

c. High temperature hot-water temperature, from 93 to 260 degrees C (200 to 500 degrees F).

d. Chilled water temperature, from minus one to 27 degrees C (30 to 80 degrees F).

e. Dual temperature water, from minus one to 116 degrees C (30 to 240 degrees F).

f. Heating hot water temperature, from 38 to 121 degrees C (100 to 250 degrees F).

g. Condenser water temperature, from minus one to 54 degrees C (30 to 130 degrees F).

h. Outside air temperature, from minus 34 to 54 degrees C (30 to 130 degrees F).

i. Relative humidity, from 0 to 100 percent for high/low limit applications; from 20 to 80 percent for space applications.

j. Differential pressure for VAV supply duct static pressure from 0 to 498 Pa (0 to 2.0 inches water) gage.

k. Pitot tube airflow measurement station and transmitter, from 0 to 25 Pa (0 to 0.1 inch water) gage for flow velocities of 2.50 to 6 m/s (500 to 1200 fpm), 0 to 62 Pa (0 to 0.25 inch water) gage for velocities of 2.50 to 9 m/s (500 to 1800 fpm), or 0 to 124 Pa (0 to 0.5 inch water) gage for velocities of 2.50 to 13 m/s (500 to 2500 fpm), or 0 to 374 Pa (0 to 1.5 inches water) gage for velocities of 7.5 to 23 m/s (1500 to 4500 fpm), or 0 to 498 Pa (0 to 2 inches water) gage for velocities of 15 to 30 m/s (3000 to 6000 fpm) as required by the duct system.

l. Electronic airflow measurement station and transmitter, from 0.64

to 13 m/s (125 to 2500 fpm), 7.5 to 23 m/s (1500 to 4500 fpm), or 15 to 30 m/s (3000 to 6000 fpm) as required by the duct system.

2.6.2 Temperature Sensors

2.6.2.1 Resistance Temperature Detectors (RTD's)

RTD shall be platinum with a tolerance of plus or minus 0.25 percent at 0 degrees C (32 degrees F), and shall be encapsulated in epoxy, Series 300 stainless steel, anodized aluminum, or copper. RTD shall be furnished with RTD transmitter as specified, integrally-mounted unless otherwise indicated.

2.6.2.2 Continuous Averaging RTD's

Continuous averaging RTD's shall have a tolerance of plus or minus 0.55 degrees C (1.0 degrees F) at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross section in which it is installed. Sensing element shall have a bendable copper sheath. Averaging RTD shall be furnished with RTD transmitter as specified, to match the resistance range of the averaging RTD. Element length shall be a minimum of 3280 mm per square meter (one linear foot per square foot) of coil face area.

2.6.2.3 RTD Transmitter

RTD transmitter shall be selected to match the resistance range of the RTD. Transmitter shall be a two-wire, loop-powered device. Transmitter shall produce a linear 4 to 20 mA dc output corresponding to required temperature measurement. Output error shall not exceed 0.1 percent of the calibrated measurement. Transmitter shall include offset and span adjustments.

2.6.2.4 Pneumatic Temperature Transmitter

Transmitting sensing elements shall be bi-metal, averaging element and capillary, rod and tube, or bulb and capillary. Transmitters shall operate within the range of 4 to 116 degrees C (40 to 240 degrees F). Provide the following spans and allowable deviations for applications listed.

a. Room sensors, minus 4 degrees C (25 degrees F), plus or minus 0.28 degrees C (0.5 degrees F)

b. Room, chilled water, dew point, return air sensors, 10 degrees C (50 degrees F), plus or minus 0.42 degree C (0.75 degree F)

c. Outside air, hot water, coil discharge sensors, 38 degrees C (100 degrees F), plus or minus 0.56 degree C (1.0 degree F)

d. High temperature hot water, chilled hot water system sensors, 93 degrees C (200 degrees F), plus or minus 1.11 degrees C (2.0 degrees F).

2.6.3 Relative Humidity Instruments

2.6.3.1 Relative Humidity Sensor

Provide relative humidity sensor. Use nonsaturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. Sensing elements shall be bulk polymer or thin film polymer. Sensing elements shall have an accuracy of plus or minus 2 percent of full scale within the range of 20 to 80 percent relative humidity. Provide a two-wire, loop-powered transmitter located at the sensing elements to convert the sensing elements output to a linear 4 to 20 mA dc output corresponding to required humidity measurement. Output error shall not exceed 0.1 percent of calibrated measurement. Transmitter shall include offset and span adjustments. Transmitter shall have ability to be calibrated electronically by using a one-point, in-situ method which allows for error correction with a single potentiometer.

2.6.4 Dew Point Instruments

Provide analog salt-phase transition or dual chilled, mirror type sensor. Sensor shall have an allowable deviation of plus or minus 0.55 or 2 degrees C (one or 3 degrees F) dew point over the range of minus 12 to plus 27 degrees C (10 to 80 degrees F) dew point.

2.6.5 Airflow Sensors

Provide airflow sensors.

2.6.5.1 Electronic Airflow Measurement Stations and Transmitters

a. Stations shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. Velocity sensing elements shall be RTD or thermistor type, with linearizing means. Sensing elements shall be distributed across the duct cross section in the quantity and pattern set forth for measurements and instruments in accordance with ASHRAE FUN SI (ASHRAE FUN IP) and SMACNA 1780, for traversing of ducted airflows. Resistance to airflow through the airflow measurement station shall not exceed 20 Pa (0.08 inch water) gage at airflow of 10 m/s (2000 fpm). Station construction shall be suitable for operation at airflows of up to 25.40 m/s (5000 fpm) over a temperature range of 4 to 49 degrees C (40 to 120 degrees F), and accuracy shall be plus or minus 3 percent over a range of 0.64 to 12.70 m/s (125 to 2500 fpm) scaled to air volume. Use stations if required velocity measurement is below 2.50 meters per second (500 feet per minute).

b. Transmitters shall produce a linear, temperature compensated 4 to 20 mA dc output corresponding to required velocity pressure measurement. Transmitters shall be a two-wire, loop-powered device. Output error of transmitters shall not exceed 0.5 percent of calibrated measurement. Transmitters shall have offset and span adjustments.

2.6.5.2 Pitot Tube Airflow Measurement Stations and Transmitters

a. Stations shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. Velocity sensing elements shall be multiple pitot tube type with averaging manifolds. Sensing elements shall be distributed across the duct cross section in the quantity and pattern set forth for measurements and instruments in accordance with ASHRAE FUN SI (ASHRAE FUN IP) or SMACNA 1780, for traversing of ducted airflows.

Resistance to airflow through the airflow measurement station shall not exceed 20 Pa (0.08 inch water) gage at airflow of 10 m/s (2000 fpm). Station construction shall be suitable for operation at airflows of up to 25.40 m/s (5000 fpm) over a temperature range of 4 to 49 degrees C (40 to 120 degrees F), and accuracy shall be plus or minus 3 percent over a range of 2.5 to 12.7 m/s (500 to 2500 fpm) scaled to air volume. Do not use stations if required velocity measurement is below 2.50 meters per second (500 feet per minute).

b. Transmitters shall produce a linear 4 to 20 mA dc output corresponding to the required velocity pressure measurement. Each transmitter shall have a low-range differential pressure sensing element and a square root extractor. The transmitter shall be a two-wire, loop powered device. Sensing element accuracy shall be plus or minus 1 percent of full scale, and overall transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement. Each transmitter shall have offset and span adjustments.

2.6.6 Pressure Sensors

Provide electronic pressure sensor and transmitter. Sensor shall be a pressure transmitter with an integral sensing element. Sensor over pressure rating shall be 172 kPa (gage) (25 psig) above its normal operating range. Sensing element accuracy shall be plus or minus one percent of full scale. Transmitter accuracy shall be plus or minus 0.1 percent of the calibrated measurement. Transmitter shall be a two-wire, loop-powered device. Transmitter shall produce a linear 4 to 20 mA dc output corresponding to required pressure measurement. Transmitter shall have offset and span adjustments.

2.7 THERMOWELLS

Provide brass or Series 300 stainless steel thermowells with threaded brass plug and chain, 50 mm (2 inch) lagging neck and extension type well, and inside diameter and insertion length as required for the application. Provide thermowells for immersion sensors with conducting material inside the well.

2.8 THERMOSTATS

Provide thermostats.

2.8.1 Ranges

Thermostat ranges shall be selected so that the setpoint is adjustable without tools between plus or minus 5 degrees C (plus or minus 10 degrees F) of the setpoint indicated.

2.8.2 Nonmodulating Electric Room Thermostats

Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be one degree C (2 degrees F). Thermostat covers shall consist of locking metal or heavy-duty plastic, and shall be capable of being locked by an Allen wrench or special tool. Thermostats shall have manual switches as required by the application and a minimum range of 13 to 32 degrees C (55 to 90 degrees F).

2.8.3 Microprocessor-Based Room Thermostats

Microprocessor-based room thermostats shall have built-in keypads for scheduling of day and night temperature settings. Access to the scheduling mode shall be by password control code. When out of the scheduling mode, thermostats shall have continuous 12-hour time display, with AM and PM indication, continuous display of day of the week, and either continuous display of room temperature with display of temperature setpoint on demand, or continuous display of temperature setpoint with display of room temperature on demand. In the programmable mode, use the display for setting and interrogating time program ON-OFF setpoints for each day of the week. The time program shall allow two separate temperature setback intervals per day. Thermostats shall have a means for temporary and manual override of program schedule, with automatic program restoration on the following day. Thermostats shall have a replaceable battery to maintain timing and to maintain the schedule in memory for one year in the event of a power outage. Maximum differential shall be one degree C (2 degrees F). Where used for heat pump applications, thermostat shall have an emergency heat switch.

2.8.4 Nonmodulating Capillary Thermostats and Aquastats

a. Thermostat shall have a capillary length of at least 1 1/2 meters (5 feet), adjustable direct reading scales for both setpoint and differential, and a differential adjustable from 3 to 9 degrees C (6 to 16 degrees F).

b. Aquastats shall be strap-on type, with 5.50 degrees C (10 degrees F) fixed differential.

2.8.5 Low-Temperature Protection Thermostats (Freezestats)

Low-temperature protection thermostats shall be manually reset low-temperature safety thermostats, with NO and NC contacts or a two-position pneumatic output signal and a 6 meters (20 foot) element which shall respond to the coldest 456 mm (18 inch) segment.

2.8.6 Modulating Capillary Thermostats

Thermostats shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. 7Thermostats shall have adjustable throttling ranges of 2 to 4 degrees C (4 to 8 degrees F) for each output.

2.8.7 Modulating Pneumatic Room Thermostats

Two-temperature combination thermostats shall be adjustable proportioning type with dual setpoints containing two temperature sensing elements: one for heating control and one for cooling control; two for heating control or two for cooling control. Changeover for two-temperature combination thermostats shall be accomplished by a change in control air supply pressure which selects proper setpoint and proper controller action. Single-temperature thermostats shall be adjustable proportioning type with one temperature sensing element: one setpoint and proper controller action. "Dead-band" thermostats shall have one adjustable proportioning type controller with two setpoints, adjustable dead-band, and one controller output or two adjustable proportioning type controllers mounted on a common backplate with two setpoints, adjustable dead-band, and two controller outputs. Temperature sensing elements shall be selected for proper controller action. Individual temperature-sensing elements shall have a separate adjustable throttling range of one to 5.50 degrees C (2 to 10 degrees F); thermostat shall have a minimum range of 13 to 32 degrees C (55 to 90 degrees F) and minimum safe air input pressure of 172 kPa (gage) (25 psig). Dead-band setting shall have a minimum adjustable range of 2 to 8 degrees C (4 to 15 degrees F). Room thermostat shall have concealed setpoint dial, covers with Allen screws, aspirator type wall box with flush plate and locking screws, built-in concealed thermometers, exposed adjustment covers with visible thermometers for family housing, and plug-in gage ports.

2.8.8 Modulating, Insertion, Immersion, & Averaging Pneumatic Thermostats

Thermostats shall be two-pipe, pilot-operated type with pneumatic feedback, proportional action and shall have an adjustable throttling range of one to 55 degrees C (2 to 100 degrees F) with a minimum range of minus 12 to plus 121 degrees C (10 to 250 degrees F). Averaging elements shall be 825 mm (1 foot) in length for each square meter (4 square feet) of ductwork cross-sectional area with a minimum length of 2.44 meters (8 feet).

2.8.9 Nonmodulating Pneumatic Thermostats

Thermostats shall have integral positive acting relays, zero or maximum output pressure. Remote element thermostats shall have standard or averaging bulbs. Averaging bulbs shall be 825 mm (one foot) in length for each square meter (4 square feet) of ductwork cross-sectional area and a minimum length of 2.44 meters (8 feet). Differential ranges shall be field adjustable. Remote element thermostat differential range shall be one to 14 degrees C (2 to 25 degrees F) with minimum control ranges of minus 23 to plus 121 degrees C (minus 10 to plus 250 degrees F). Room thermostat differential range shall be one to 5.50 degrees C (2 to 10 degrees F) with minimum control ranges of 13 to 32 degrees C (55 to 90 degrees F).

2.9 SUNSHIELDS

Provide sunshields for outside air temperature sensing elements to prevent the sun from directly striking temperature sensing elements. Provide sunshields with adequate ventilation so that the sensing element responds to the ambient temperature of surroundings. The top of each sunshield shall have galvanized metal or aluminum rain shield projecting over the face of the sunshield. Sunshields shall be painted white or shall be unpainted aluminum.

2.10 PRESSURE SWITCHES AND SOLENOID VALVES

Provide pressure switches and solenoid valves.

2.10.1 Pressure Switches

Switches shall have an adjustable setpoint with visible setpoint scale. Range shall be as indicated. Differential adjustment shall span 20 to 40 percent of the range of the device.

2.10.2 Differential Pressure Switches

Switches shall be an adjustable diaphragm-operated device with two SPDT or one SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. Fittings shall be angled-tip type with tips pointing into the airstream. Range shall be 125 to 1494 Pa (0.5 to 6 inches water) gage. Differential shall be a maximum of 37 Pa (0.15 inch water) gage at the low end of the range and 87 Pa (0.35 inch water) gage at the high end of the range.

2.10.3 Pneumatic Electric (PE) Switches

Switches shall have an adjustable setpoint range of 21 to 138 kPa (gage) (3 to 20 psig), and differential adjustable from 14 to 41, 7to 14, or 2 to 7 kPa (2 to 6, 1 to 2, or 0.25 to 1 psi).

2.10.4 Solenoid Operated Pneumatic (EP) Valves

Valves shall have three-port operation: common, normally open, and normally closed. Valves shall have an outer cast aluminum body. The air connection shall be a 6 mm (1/4 inch) NPT threaded connection. Valves shall be rated for 345 kPa (gage) (50 psig) where used in a control system which operates at 172 kPa (gage) (25 psig) or less, or 1034 kpa (gage) (150 psig) where used in a control system which operates in the range of 172 to 689 kPa (gage) (25 to 100 psig).

2.11 INDICATING DEVICES

Provide indicating devices.

2.11.1 Thermometers

a. Thermometers for insertion in ductwork and piping systems shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, and permanently stabilized glass tube with an indicating fluid column, white face, black numbers, and a 229 mm (9 inch) scale.

b. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern.

c. Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid stem thermometers, the space between bulb and stem shall be filled with a heat transfer medium.

d. Air duct thermometers shall have perforated stem guards and 45 degree adjustable duct flanges with locking mechanisms.

e. Averaging thermometers shall have 90 mm (3.5 inch) (nominal) dial, with black legend on white background, and pointer traveling through a 270 degree arc.

f. Thermometers shall have an accuracy of plus or minus one percent of scale range. Thermometers shall have the following ranges:

(1) Mixed air temperature: minus 18 to plus 38 degrees C in 1/2 degree C (0 to 100 degrees F in 1 degree F) graduations.

(2) Return air temperature: minus 18 to plus 38 degrees C in 1/2 degrees C (0 to 100 degrees F in 1 degree F) graduations.

(3) Cooling coil discharge temperature: minus 18 to plus 38 degrees C in 1/2 degree C (0 to 100 degrees F in 1 degree F) graduations.

(4) Heating coil discharge temperature: minus one to plus 82 degrees C in one degree C (30 to 180 degrees F in 2 degree F) graduations.

(5) Hydronic heating systems below 104 degrees C (220 degrees F): 4 to 116 degrees C in one degree (40 to 240 degrees F in 2 degree) graduations.

(6) Chilled water temperature: minus 18 to plus 38 degrees C in 1/2 degree C (0 to 100 degrees F in one degree F) graduations.

(7) Condenser water temperature: 4 to 60 degrees C in 1/2 degree C (40 to 140 degrees in one degree F) graduations.

(8) Glycol temperature: minus 18 to plus 38 degrees C (0 to 100 degrees F)for cooling service in 1/2 degree C (one degree F) graduations, and 4 to 116 degrees C (40 to 240 degrees F) for heating service in one degree C (2 degree F) graduations.

(9) High temperature hot water: 38 to 288 degrees C in 3 degree C (100 to 550 degrees F in 5 degree F) graduations.

2.11.2 Pressure Gages

Provide pressure gages with gage cock, snubber, and syphon.

a. ASME B40.100. Gages shall be 65 mm (2 1/2 inch) (nominal) size, back-connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270 degree arc. Accuracy shall be plus or minus 3 percent of scale range.

b. Gages for indicating signal output to pneumatic actuators and main air gages shall have scale of 0 to 210 kPa (gage) in 10 kPa (0 to 30 psig in 1 psig) graduations.

c. Gages for air storage tanks and for use before and after dirt and oil filters or dryers, shall have a scale of 0 to 1100 kPa (gage) (0 to 160 psig) with 15 Kpa (gage) (2 psig) graduations.

d. Gages for hydronic and steam system applications shall have ranges and graduations as indicated.

e. Pneumatic transmission receiver gages shall have a range to match the respective transmitters.

2.12 LOW-DIFFERENTIAL PRESSURE GAGES

Gages for low-differential pressure measurements shall be 115 mm (4 1/2 inch) (nominal) size with two seats of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gages shall have ranges and graduations as indicated. Accuracy shall be plus or minus 2 percent of scale range.

2.13 CONTROLLERS

2.13.1 Single-Loop Controllers

2.13.1.1 Controller Features

Controller shall be a microprocessor-based, single-loop device that does not require Contractor-generated software. Controller shall conform to FCC Part 15. Controller panel cutout shall be 92 by 92 mm (3.62 by 3.62 inches). Controller shall have field selectable range for process variables, a remote setpoint analog input and analog output with adjustable high and low end limits, and proportional control manual reset adjustment. Analog output shall result from PID control. Analog output shall be configurable as direct acting and reverse acting. Controller shall have keyboard, display, auto/manual selection for control of analog output, and remote setpoint adjustment/local setpoint adjustment selection. Controller shall have adjustable high-end and low-end limits, ratio, and bias adjustments on remote setpoint input; operator initiated self-tune/manual-tune selection, anti-reset wind-up feature, and two configurable independent SPDT with adjustable system contact closure outputs. Controller shall be configurable to power-up in manual with local setpoint control, in automatic with local setpoint control, and in automatic with remote setpoint control. Contact closures shall be activated by a process variable and by a process variable deviation from setpoint as configured. The range of hysteresis adjustment shall not be smaller than 1 percent to 5 percent of process variable input span. Controller shall power the analog output loop to 20 mA where connected to a load of 600 ohms. Controller shall have 5-year battery backup or shall have nonvolatile memory to store operating parameters.

2.13.1.2 Controller Parameter Input and Display

Control parameters shall be entered and displayed directly, in the correct engineering units, through a series of keystrokes on a front panel display with a 3 1/2-digit, seven-segment display, with decimal point and polarity indication. Use of the display shall allow manual interrogation of setpoint, mode constants, and values of process variables and outputs.

2.13.1.3 Controller Electrical Requirements

Controller shall be powered by 120 Vac. Controller shall provide electrical noise isolation, not less than 100 dB at 60 Hz common mode rejection ratio, and not less than 60 dB at 60 Hz normal mode rejection ratio between ac power line and process variable input, remote setpoint input, and output signals.

2.13.1.4 Controller Accuracy

Controller shall have an accuracy of plus or minus 0.30 percent of input span, plus or minus one digit.

2.13.1.5 Controller Self Tuning

Controller self-tuning operation shall apply proportional, integral, and derivative modes of control; mode constants shall be modified as required. Self tuning shall only operate when selected from the front panel.

2.13.1.6 Controller Manual Tuning

Controller manual tuning operation shall provide proportional, integral, and derivative control modes, or any combination thereof, by means of individual mode constant adjustments. Adjustments shall be set for the appropriate value if a particular control mode action is desired, or to zero for the particular mode not desired. The proportional mode constant shall be adjustable from 0 to 200 percent of input signal range; the integral mode constant shall be adjustable from 0 to 20 repetitions per minute; and the derivative mode constant shall be adjustable from 0 to 5 minutes.

2.13.2 Pneumatic Controllers

Controllers shall be two-pipe devices which use main air supplied to controller and pneumatic relay to produce the controller output signal. Controllers shall have field selectable local and remote adjustable setpoints, and an adjustable proportional band for analog (proportional) control or an adjustable differential for binary (two-position or floating) control. Controllers shall have single- or dual-input ports as required for the application and field selectable direct or reverse action for inputs. Dual input controllers shall have adjustable secondary input authority. Controllers shall have integral gage or test connections for testing or indication of input and output signals.

2.13.3 Analog Electronic Controllers

Controllers shall be solid-state electronic devices which sense the difference between input sensor analog values (resistance or voltage) and setpoint adjustment analog values (resistance or voltage), and shall amplify the difference signal to provide the output signal. Controllers shall include the following:

a. Proportional band: 2.5 to 33 percent of input device span.

b. Authority: minimum of 33 to 200 percent.

c. Inputs: thermistor, resistance, transmitter, or output of other electronic controllers.

d. Outputs: within the range of minus 5 to 20 Vdc or a 4 to 20 mA dc current loop.

e. Remote setpoint adjustment (SPA): plus or minus 10 percent of input device span.

2.13.4 Unitary Control Systems

Unitary control systems shall be energy-efficient, micro-processor-based temperature controllers and associated devices that do not require Contractor-generated software. Provide control systems with integral or remote sensor as indicated. Controllers shall operate heating, cooling, and ventilating modes with independent occupied and unoccupied settings for each of 7 consecutive days. Cooling shall be controlled in two or three steps and heating shall be controlled in two, three, or four steps with modulating control provided for the ventilation mode. Provide temperature changeover control to limit the ventilation mode when outdoor air temperature is not sufficiently low for "free-cooling." Provision shall be made for automatic or manual changeover between heating and cooling modes, providing a one minute minimum time delay between the start and stop operation of heating and cooling stages upon startup and after power failure to prevent short cycling and power surges. Provide an optimum startup program to minimize warm-up or cool-down periods prior to the occupied mode. Outside air dampers shall be closed during the optimum startup program unless outside air is beneficial for cool-down in lieu of mechanical cooling. Fan shall operate continuously during the occupied mode and shall cycle during the unoccupied mode for heating or cooling. Provide battery backup to retain programs and maintain clock operation for 48 hours minimum during power outages. Controller shall have a self-diagnostic program to indicate errors and locking covers to prevent unauthorized program entries. Provide a convenient means to restore the occupied mode of operation for a minimum 2-hour period without removing covers. An indexing switch shall allow operation in a continuous unoccupied mode during abnormal periods without changing normal programs. Servicing tool required to place the unitary control system in use shall be a hand-held device used to adjust and monitor setpoints, controlled device positions, input sensor values, and other control system parameters.

2.13.5 Pneumatic Low-Range Pressure Controllers for Ductwork Applications

Controllers shall provide two-pipe, pilot-operated control with pneumatic feedback and proportional action. Sensing elements shall be differential type with pressure ranges appropriate for intended service. One element shall measure the variable while the other element measures the standard reference. Static pressure controllers shall have slack diaphragms with standard ranges between 0 to 1494 Pa (0 to 6 inches water) gage and an adjustable throttling range of 5 to 125 Pa (0.02 to 0.5 inch water) gage. Sensing element shall be mountable in ductwork and shall measure static pressure without pulsations.

2.13.6 Pneumatic Differential Pressure Controllers for Liquid Applications

Differential pressure controllers shall have a minimum range of 0 to 345 kPa (gage) or 0 to 1724 kPa (gage) (0 to 50 psig or 0 to 250 psig) as specified or required for the application and shall have an adjustable throttling range of 7 to 172 kPa (gage) (1 to 25 psig). Sensing element shall be filled diaphragm type with three-valve manifold for isolation and nulling. Provide syphons and pressure snubbers.

2.14 CONTROL DEVICES AND ACCESSORIES

Provide control devices and accessories.

2.14.1 Function Modules

Function modules shall accept mA dc analog input signals to produce analog output signals or contact output signals. Modules shall have zero and span adjustments for analog outputs, and setpoint adjustments for contact outputs.

2.14.1.1 Minimum Position Switches and Temperature Setpoint Devices

Minimum position switches and temperature setpoint devices shall accept manual input and shall produce steady analog output. Switches and devices shall be suitable for recessed wall mounting or panel mounting and shall have a graduated dial.

2.14.1.2 Signal Inverter Modules

Signal inverter modules shall accept analog input signal and produce analog output signal that linearly reverses the direction of signal change of input versus output.

2.14.1.3 High-Low Signal Selector Modules

High-low signal selector modules shall accept analog input signals and select either the highest or the lowest input signal as the output signal.

2.14.1.4 Sequencer Modules

Sequencer modules shall provide fixed time delayed sequencing of one or more contact transfers from an analog input signal. Sequencers shall return contacts to their zero input signal condition when power is interrupted.

2.14.2 Relays

Relays shall be two-pole, double-throw (DPDT) with a 10-ampere resistive rating at 120 or 24 Vac, and shall have an enclosed coil. Provide with a light indicator which is lit when the coil is energized and is not lit when the coil is not energized.

2.14.3 Time-Delay Relays

Time-delay relays shall be DPDT with octal connectors and dust covers. The adjustable timing range shall be 0 to 3 minutes.

2.14.4 Time Clocks

Time clocks shall be a 24-hour, 365-day programmable timing device with two independently timed circuits. Clocks shall have a manual scheduling keypad and alphanumeric display of timing parameters. Timing parameters shall include Gregorian calendar date for month, day and day-of-month indication; and 24-hour time-of-day display, with one-minute resolution for programming the ON and OFF times for each circuit. Circuits shall have programmable timed override from 1 to 99 minutes. Clocks shall have capacity for programming four ON events and four OFF events for each circuit. Programmed events shall be assignable to a 365-day schedule. Clocks shall have automatic standard time and daylight saving time adjustments, keyed to input of appropriate dates. Provide clocks with 4-day battery backup.

2.14.5 Override Timer

Override timers shall be manually set, mechanically driven timers, or electronic timers, without a "hold" feature. Time intervals shall be selectable for up to 12 hours of operation and shall expire unless reset.

2.14.6 Current-to-Pneumatic (IP) Transducers

Transducers shall be two-wire transmitters which convert an input signal to 21 to 103 kPa (gage) or 103 to 21 kPa (gage) (3 to 15 psig or 15 to 3 psig) pneumatic output, with a conversion accuracy of plus or minus 2 percent of full scale, including linearity and hysteresis. Air consumption shall not be greater than 0.12 L/s (0.25 scfm).

2.14.7 Regulated Power Supplies

Power supplies shall provide a 24-Vdc linear supply at not less than 2 amperes, with regulation to 0.05 percent of output voltage. Power supplies shall have a fused input, and shall be protected from voltage surges and power-line transients. Power supply output shall be protected against over-voltage and short circuits. Power supply loading shall not be greater than 1.2 amperes.

2.14.8 Transformers

UL 508 and NEMA ST 1 as applicable. Transformers, other than transformers in bridge circuits, shall have primaries wound for available voltage and secondaries wound for correct control circuit voltage. Transformers shall be sized so that connected loads equal 80 percent of rated capacity. Transformers shall be enclosed in rustproof, galvanized steel cabinets with conduit connections. Disconnect switch shall be provided on the primary side, and a fuse cutout on the secondary side. For systems indicated, provide backup power supply including transformers connected to the emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit.

2.14.9 Pilot Lights and Manual Switches

Device illumination shall be by light-emitting diode (LED) or neon lamp. Switches shall have operating levers and index plates showing switch positions and names of apparatus controlled or other appropriate designations.

2.15 HVAC SYSTEM CONTROL PANELS

Provide HVAC system control panels.

2.15.1 Panel Assembly

Panel shall be fabricated for bottom entry connection for control system electric power, control system main air source, control system wiring, pneumatic tubing, interconnection of control systems, interconnection of starters, and external shutdown devices. Panel shall have an operating temperature rise of not greater than 11 degrees C (20 degrees F) above an ambient temperature of 38 degrees C (100 degrees F).

2.15.2 Panel Electrical Requirements

Control panel shall be powered by nominal 120 Vac terminating at panel on terminal blocks. Instrument cases shall be grounded. Interior and exterior panel enclosures shall be grounded.

2.15.3 Enclosures

Enclosures for each panel shall be a single door, wall-mounted box conforming to NEMA 250 with a continuous hinged and gasketed exterior door with a print pocket, key lock, and interior back panel. Inside finish shall be white enamel, and outside finish shall be gray primer over phosphatized surfaces.

2.15.4 Mounting and Labeling

Provide pilot lights, switches, panel-mounted control devices, and pressure gages shall be mounted on the door. Power conditioners, fuses, and duplex outlets shall be mounted on the interior of the cabinet. Other components housed in the panel shall be mounted on the interior back panel surface of the enclosure and shall be identified by plastic or metal nameplates which are mechanically attached to the panel. Lettering shall be cut or stamped into the nameplate to a depth of not less than 0.4 mm (1/64 inch), and shall have contrasting color, produced by filling with enamel or lacquer or by use of laminated material. Painting of lettering directly on the surface of the door or interior back panel is not permitted.

2.15.5 Wiring and Tubing

a. Pneumatic device inputs and outputs shall be piped to bulkhead fittings in the bottom of the panel with a 50 mm (2 inch) loop to facilitate replacement. Electric, electronic, and electropneumatic device signals entering and leaving the panel shall be wired to identified terminal blocks.

b. Wiring shall be installed in wiring ducts so that devices can be added or replaced without disturbing existing wiring that is not affected by the change. Wiring to single-loop controllers shall have a 100 mm (4 inch) wiring loop in the horizontal wiring duct at each wiring connection. There shall be no wiring splices within the control panel. Interconnections required for power or signals shall be made on device terminals, if available, or panel terminal blocks, with not more than two wires connected to each terminal.

c. Instrument signal grounds at the same reference level shall end at a grounding terminal connected to a common ground point for that level. Wiring shield grounds at the same reference level shall end at a grounding terminal connected to a common ground point for that level. Grounding terminal blocks shall be identified by reference level.

d. Wiring connected to controllers shall be identified by function and polarity, e.g., process variable input and remote setpoint input and output.

2.16 COMPRESSED AIR STATIONS

Provide compressed air stations.

2.16.1 Air Compressor Assembly

a. Compressor shall be equipped with an electric motor with a totally enclosed belt guard, operating pressure switch, safety relief valves, gages, intake filter, and intake silencer. Compressor shall have combination type magnetic starter with undervoltage protection and thermal overload protection for each phase. Compressor shall be supported by a steel base mounted on an air storage tank. Air compressor shall be sized to supply compressed air required by the control system while operating not more than one-third of the time.

b. Compressor shall be a duplex machine. Compressor shall be equipped with an electric motor with a totally enclosed belt guard, operating pressure switch, safety relief valve, cylinder unloader or solenoid unloader, intake filter, and intake silencer. Provide an alternator and two magnetic starters with undervoltage protection and thermal overload protection for each phase. Compressors shall be supported on a steel base mounted on an air storage tank. Compressor shall be sized to the control system compressed air requirement while operating not more than one-half of the time.

c. Compressed air storage tank shall be fabricated for working pressure of not less than 1379 kPa (gage) (200 psig), and constructed and certified in accordance with ASME BPVC. Tank shall be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 138 kPa (20 psi) differential. Tank shall be provided with an automatic condensate drain trap with a manual override feature.

2.16.2 Compressed Air Station Specialties

a. Pressure regulator and refrigerated air dryer shall be provided in the air outlet line of the air storage tank. Dryer shall be sized for full air delivery capacity of compressor. Air shall be dried at a pressure of not less than 483 kPa (gage) (70 psig) to a temperature not greater than 2 degrees C (35 degrees F). Dryer shall be provided with an automatic condensate drain trap with a manual override feature.

b. Two parallel combination dirt and coalescing type oil filters with shutoff valves and pressure regulators shall be provided in the dryer discharge. Air filtration system shall be rated for full delivery capacity of compressor. Filter shall be 100 percent efficient for particle diameters down to 0.3 microns. Filter bowl shall be rated for 1034 kPa (gage) (150 psig) maximum working pressure. One of the filters shall serve as a standby. Pressure regulator and safety valve shall be provided downstream of the filter.

c. Flexible pipe connectors shall be designed for 1034 kPa (gage) and 121 degrees C (150 psi and 250 degrees F) service, and shall be constructed of rubber, tetrafluoroethylene resin, or braided corrosion-resistant steel, bronze, monel, or galvanized steel. Connectors shall be suitable for service intended and may have threaded or soldered ends. Length of connectors shall be as recommended by the manufacturer for service intended.

d. Vibration isolation units shall be standard products with published loading ratings, and shall be single rubber-in-shear, double rubber-in-shear, or spring type.

2.17 ELECTRONIC VARIABLE AIR VOLUME VAV TERMINAL UNIT CONTROLS

Provide electronic VAV terminal unit controls.

2.17.1 VAV Terminal Units

VAV terminal units shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS.

2.17.2 Terminal Unit Controls

a. UL 916 and FCC Part 15. Controls for pressure independent boxes shall consist of a velocity sensing device in the primary air entering box, a room temperature sensing element, a damper actuator, and an adjustable microprocessor-based VAV box controller. Controls shall operate a damper for cooling and a duct coil for heating. Actuator shall open or close the device to which it is applied within 6 minutes.

b. Controls for pressure independent boxes with recirculating fans shall consist of a velocity sensing device in the primary air entering the box, a room temperature sensing element, an adjustable microprocessor-based VAV box controller, a damper with actuator, and a duct pressure switch to operate the recirculation fan. Controller shall operate the damper for cooling and the recirculating fan and duct coil for heating.

c. One hand-held communication and programming device with an instruction manual, plus one additional hand-held communication device and instruction manual per 100 terminal units, shall be provided. Communication and programming device shall connect directly to the controller or to a jack at the room temperature sensing element location. Communication and programming device shall be used to read and set minimum velocity, maximum velocity, heating setpoint, and cooling setpoint, and to read air velocity and space temperature.

2.18 CONTROL TUBING AND WIRING

Provide HVAC control tubing and wiring.

2.18.1 Tube and Fittings

2.18.1.1 Copper Tubing

ASTM B75/B75M or ASTM B88M (ASTM B88). Tubing 10 mm (0.375 inch) outside diameter and larger shall have a minimum wall thickness equal to ASTM B88M (ASTM B88), Type M. Tubing less than 10 mm (0.375 inch) outside diameter shall have a minimum wall thickness of 0.64 mm (0.025 inch). Concealed tubing shall be hard or soft copper; multiple tubing shall be racked or bundled. Exposed tubing shall be hard copper; rack multiple tubing. Tubing for working pressures greater than 206 kPa (gage) (30 psig) shall be hard copper. Bundled tubing shall have each tube numbered each 2.0 meters (six feet) minimum. Racked and individual tubes shall be permanently identified at each end. Fittings shall be solder type ASME B16.18 or ASME B16.22, using ASTM B32, Plumbing Code approved lead-free solder, or compression type ASME B16.26.

2.18.1.2 Polyethylene Tubing

Polyethylene tubing shall be provided only for systems with working pressure of 206 kPa (gage)(30 psig) or less. Provide flame-resistant, multiple polyethylene tubing in flame-resistant protective sheath with Mylar barrier, or unsheathed flame-resistant polyethylene tubing in rigid metal, intermediate metal, or electrical metallic tubing conduit for areas where tubing is exposed. Single, unsheathed, flame-resistant polyethylene tubing may be used where concealed in walls or above ceilings and within control panels, except prohibited in crawl spaces, attics, and above-ceiling spaces that are vented to the outdoors. Do not provide polyethylene tubing for systems indicated as critical and smoke removal systems. Number each tube in sheathing each two feet minimum. Permanently identify unsheathed tubing at each end. Provide compression or barbed push-on type fittings. Extruded seamless polyethylene tubing shall conform to the following:

a. Minimum burst pressure requirements: 690 kPa (gage) at 24 degrees C to 172 kPa (gage) at 66 degrees C (100 psig at 75 degrees F to 25 psig at 150 degrees F).

b. Stress crack resistance: ASTM D1693, 200 hours minimum.

c. Tensile strength (minimum): ASTM D638 (ASTM D638), 7583 kPa (1100 psi).

d. Flow rate (average): ASTM D1238, 0.30 decigram per minute.

e. Density (average): ASTM D792, 920 kg/m3 (57.5 pounds per cubic feet).

f. Burn rate: ASTM D635.

2.18.2 Wiring

a. Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanisms. Terminal blocks shall be rail mounted, and shall have end plates, partition plates or enclosed sides for separation.

b. Control wiring for 24-V circuits shall be 18 AWG minimum and shall be rated for 300-V service.

c. Wiring for circuits operating at more than 100 V shall be 14 AWG minimum and shall be rated for 600-V service.

d. Analog signal wiring circuits within control panels shall not be less than 20 AWG and shall be rated for 300-V service.

e. Instrumentation cable shall be 18 AWG, stranded copper, single or multiple twisted, minimum 2-inch lay of twist, 100 percent shielded pairs, and shall have 300-V insulation. Each pair shall have a 20-AWG tinned copper drain wire, individual pair, and overall insulation. Cables shall have an overall aluminum polyester or tinned overall copper cable shield tape, 20-AWG tinned-copper cable drain wire, and overall cable insulation.

f. Nonconducting wiring ducts in control panels shall have slotted side snap-on covers, fittings for connecting ducts, mounting clips for securing ducts, and wire retaining clips.

PART 3 EXECUTION

3.1 INSTALLATION

Perform installation under the supervision of competent technicians regularly employed in the installation of control systems. Provide components for a complete and operational control system. Provide control system complete and ready for operation, as specified and indicated.

Provide dielectric isolation where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be watertight. Control system installation shall provide adequate clearance for control system maintenance by maintaining access spaces between coils, to mixed-air plenums, and as required to calibrate, remove, repair, or replace control system devices. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance. Install devices mounted in or on piping or ductwork, on building surfaces, in mechanical and electrical spaces, or in occupied space ceilings in accordance with manufacturer's recommendations and as indicated on contract documents. Provide control devices to be installed in piping and ductwork with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Certify that installation of control system is complete and technical requirements of this section have been met.

3.1.1 Sensors

Provide sensors in locations to sense the appropriate condition. Install sensor and transmitter where easily accessible and serviceable without special tools. Sensors shall be calibrated to the accuracy specified in the contract, and operate correctly when installed. Do not install sensors designed for one application in the place of another application (e.g., replacing a duct sensor with a room sensor).

3.1.1.1 Room Sensors

Provide on interior walls to sense average room conditions. Avoid locations which may be covered by office furniture. Do not mount room sensors on exterior walls if other locations are available. Mount centerline of sensor 1 1/2 meters (5 feet) above finished floor.

3.1.1.2 Duct Temperature Sensors

Provide sensors in ductwork in general locations as indicated. Select specific sensor location within duct to accurately sense appropriate air temperatures. Locate sensor connection boxes in position not obstructed by ducts or equipment. Install gaskets between sensor housing and duct wall. Seal duct and insulation penetrations. Install duct averaging sensors between two rigid supports in serpentine position to sense average conditions. Sensor shall have a total minimum length of 825 mm per square meter (one linear foot per 4 square feet) of duct area. Sensor shall be mounted a minimum of 80 mm (3 inches) from outside wall surface. Thermally isolate temperature sensing elements from supports. Provide duct access doors to averaging sensors.

3.1.1.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring temperatures in liquid applications or pressure vessels. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to effect proper flow across entire area of the well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Temperature sensors shall be installed in thermowells with thermal transmission material to speed the response of temperature measurement. Provide thermowells with sealing nuts to contain thermal transmission material.

3.1.1.4 Strap-on Temperature Sensors

Strap-on temperature sensors, using helical screw stainless steel clamps, shall be permitted on new hot water piping for on-off operation, and for existing hot water piping sizes not greater than 80 mm (3 inches). Clean the pipe to bright metal. Insulate strap-on bulb and pipe after installation. Provide other liquid temperature sensors with thermowells. Provide NEMA 250 Type 4 enclosures for outdoor installations. Provide brushed aluminum or brushed stainless steel enclosures for sensors located in finished spaces.

3.1.1.5 Outside Air Temperature Sensors

Provide outside air temperature sensor on north side of building, away from exhaust hoods, air intakes, and other areas which may affect temperature readings. Install sunshields to protect outside air temperature sensor from direct sunlight.

3.1.1.6 Low-Temperature Protection Thermostats (Freezestats)

Provide thermostat for each 7.5 square meter (80 square feet) of coil-face area to sense the temperature at location indicated. Install thermostat sensing element in serpentine pattern.

3.1.2 Thermometers

Provide thermometers which are installed in liquid systems in thermowells with thermal transmitting materials within the well to speed the response of temperature measurement.

3.1.3 Pressure Sensors

3.1.3.1 Duct Static Pressure

Duct static pressure sensor shall be located where indicated on drawings. If no location is indicated, it should be located approximately two-thirds of distance from supply fan to the end of duct with greatest pressure drop.

3.1.3.2 Steam Pressure

Provide snubbers and isolation valves on steam pressure sensing applications.

3.1.4 Pressure Gages

Provide snubbers for gages in piping systems subject to pulsation. Gages for steam service shall have pigtail fittings with cocks. Install pressure gages at locations indicated. Pneumatic output lines shall have pressure gages mounted near the control panel.

3.1.5 Valves

Provide valve with stems upright where possible but with stems not lower than horizontal. Provide positioners where indicated and where necessary to prevent overlap of heating and cooling where one controller operates more than one pneumatic device and to maintain the proper dead band between heating and cooling.

3.1.6 Damper Actuators

Provide damper actuators so that the damper sealing action is smooth and sufficient to maintain leakage at or below specified leakage rate. Multiple actuators operating a common damper shall be connected to a common drive shaft. Provide positioners where indicated and where necessary to prevent overlap of heating and cooling where one controller operates more than one pneumatic device and to maintain the proper dead band between heating and cooling.

3.1.7 Access Doors

Provide access doors in ductwork to service airflow monitoring devices, devices with averaging elements, and low-temperature protection thermostats (freezestats).

3.1.8 Tubing

a. Provide control system so that pneumatic lines are not exposed to air temperatures below minus 4 degrees C (25 degrees F). Install tubes and tube bundles exposed to view neatly in lines parallel to lines of the building. Route tubing between panels and actuators in mechanical and electrical spaces so that lines are easily traceable. Tubes shall be permanently tagged on both ends with an identifier indicated on shop drawings. Install concealed tubing in finished areas, and install exposed tubing in unfinished areas such as mechanical equipment rooms.

b. Pneumatic lines in mechanical and electrical spaces shall be plastic tubing or copper tubing. Install horizontal and vertical runs of plastic tubes or soft copper tubing in raceways dedicated to tubing. Dedicated raceways shall be supported every 2 meters (6 feet) of horizontal run and every 2.44 meter (8 feet) for vertical runs. Tubing not installed in raceways shall be hard-drawn copper tubing with sweat fittings and valves, supported every 2 meter (6 feet) of horizontal run and every 2.44 meters (8 feet) for vertical runs.

c. Tubing for connecting sensing elements and transmitters to liquid and steam lines shall be copper or Series 300 stainless steel with brass compression or stainless steel compression fittings.

d. Tubing for final connection of sensing elements and transmitters to ductwork shall be plastic with a maximum length of 305 mm (12 inches).

e. Tubing external to mechanical and electrical spaces, where run in plenum ceilings, shall be soft copper with sweat fittings, supported every 2.44 meters (8 feet). Tubing not in plenum spaces shall be soft copper with sweat fittings supported every 2.44 meters (8 feet) or shall be plastic tubing in raceways dedicated to tubing.

f. Provide tubing in concrete in rigid conduit. Install tubing in walls containing insulation, fill, or other packing materials in raceways dedicated to tubing.

g. Final connections to actuators shall be plastic tubing, a maximum of 305 mm (12 inches) long and unsupported at the actuator.

h. Provide a manual valve at each HVAC control panel to allow shutoff of main air. Pneumatic connections to HVAC control panels shall be made using bulkhead fittings except where bundled tubing is being used.

i. Final connections to HVAC control panel bulkhead fittings shall be exposed tubing approximately 305 mm (12 inches) long.

j. Tubing and two insulated copper phone wires for installation checkout may be run in the same conduit. Tubing and electrical power conductors shall not be run in the same conduit. Control circuit conductors, 24 V or less, may be run in the same conduit as polyethylene tubing.

3.1.9 Wiring

a. Provide wiring external to control panels, including low-voltage wiring, in metallic raceways. Install wiring without splices between sensors, transmitters, control devices, and HVAC control panels. Install instrumentation grounding as necessary to prevent ground loops, noise, and surges adversely affecting operation of the system. Tag cables, conductors, and wires at both ends, with identifiers indicated on shop drawings.

b. Other electrical work shall be specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide step-down transformers where control equipment operates at lower than line circuit voltages. Transformers serving individual heating, ventilating, and air-conditioning units shall be fed from fan motor leads, or fed from the nearest distribution panelboard or motor control center, using circuits provided for that purpose.

c. Ground control panels and cabinets as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Grounding of the green ac ground wire at the breaker panel alone is not adequate. Install ground wire from each control panel to adequate building ground.

3.1.10 Foundations and Housekeeping Pads

Provide 80 mm (3 inch) high concrete foundations and housekeeping pads for the HVAC control system air compressors.

3.1.11 Compressed Air Stations

Mount air compressor assembly on vibration eliminators, in accordance with ASME BPVC for tank clearance. Connect air line to the tank with a flexible pipe connector. Install compressed air station specialties with required tubing, including condensate tubing to a floor drain.

3.1.12 Control Drawings

Post laminated copies of as-built control system drawings in each mechanical room.

3.2 ADJUSTMENTS

Calibrate instrumentation and controls, and verify specified accuracy using test equipment traceable to National Institute for Science and

Technology (NIST) standards. Adjust controls and equipment to maintain conditions indicated, to perform the functions indicated, and to operate in the sequence specified.

3.3 FIELD QUALITY CONTROL

a. Demonstrate compliance of HVAC control systems. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Calibrate test equipment in accordance with NIST standards. Ensure that tests are performed or supervised by competent employees of the control system installer or the control system manufacturer regularly employed in testing and calibration of control systems.

b. Testing shall include field tests and the performance verification test. Field tests shall demonstrate proper calibration of instrumentation, input and output devices, and operation of specific equipment. The performance verification test shall ensure proper execution of sequence of operation and proper tuning of control loops.

c. The plan for each phase of field acceptance testing shall be approved in writing before beginning that phase of testing. Furnish written notification of planned testing to Contracting Officer at least 21 days prior to testing. Include proposed test procedures with notification. The Contractor will not be allowed to start testing without written Government approval of test procedures. Test procedures shall consist of detailed instructions for complete testing to prove the performance of heating, ventilating, and air-conditioning system and control system. Include the following tests in test procedures.

d. Submit original copies of data produced, including results of each test procedure, to the Government at the conclusion of each phase of testing. Tests are subject to supervision and approval by Contracting Officer. Do not perform testing during scheduled seasonal off-periods of heating and cooling systems.

3.3.1 Test Reporting

After completion or termination of field tests and again after the performance verification test, identify, determine causes, replace, repair, or calibrate equipment which fails to meet the specification; and deliver a written report to the Government. The report shall document test results, explain in detail the nature of each failure, and corrective action taken. After delivering the performance verification test report, the Contractor shall convene a test review meeting at the job site to present results and recommendations to the Government. As a part of the test review meeting, the Contractor shall demonstrate by performing appropriate portions of field tests or the performance verification test that failures have been corrected. Based on Contractor's report and test review meeting, the Government will determine either the restart point or successful completion of testing. Do not commence required retesting until after receipt of written notification by the Government. At the conclusion of retesting, repeat the assessment.

3.3.2 Contractor's Field Testing

Calibrate field equipment and verify equipment and system operation before system is placed on-line. Include the following tests in field testing.

3.3.2.1 Tubing and Wiring Integrity Tests

Test tubing system pneumatically at 1.5 times the design working pressure for 24 hours. Allowable leakage rate is that which produces a pressure drop 7 kPa (gage) (1 psig) in 24 hours with compressed air supply turned off. Test wiring for continuity, ground faults, and open and short circuits.

3.3.2.2 System Inspection

Observe HVAC control system in shutdown condition. Check dampers and valves for proper normal positions. Document positions for the performance verification test report.

3.3.2.3 Calibration Accuracy and Operation of Input Test

Verify correct calibration and operation of input instrument. For each sensor and transmitter, including for temperature, pressure, relative humidity, and dew point inputs, record the reading at the sensor or transmitter location using calibrated test equipment. Record the output reading provided by that sensor or transmitter. Document each of these location and output readings for the performance verification test report. The test equipment shall have been calibrated within one year of the date of use in the field. Test equipment calibration shall be traceable to the measurement standard of the National Institute of Standards and Technology.

3.3.2.4 Operation of Output Test

Check the operation of output to verify correct operation. Operate analog device to minimum range (e.g., 4 mA) and maximum range (e.g., 20 mA), and measure and record actual output values.

3.3.2.5 Actuator Range Adjustment

With the controller, apply a control signal to each actuator and verify that the actuator operates properly from its normal position through to the full range of stroke position. Record actual spring ranges and normal positions for modulating control valves and dampers.

3.3.3 Coordination With HVAC System Balancing

Tune the control system after air and hydronic systems have been balanced, minimum damper positions have been set, and a report has been issued.

3.3.4 Field Test Documentation

Before scheduling the performance verification test, provide field test documentation and written certification of completion to Contracting Officer that the installed system has been calibrated, tested, and is ready to begin the performance verification test. Do not start the performance verification test prior to receiving written permission from the Government.

3.3.5 Performance Verification Test

Conduct the performance verification tests to demonstrate that the control system maintains setpoints and that the control loops are tuned for the correct sequence of operation. Conduct the performance verification test during one week of continuous HVAC and control systems operation and before final acceptance of work. Specifically, the performance verification test shall demonstrate that the HVAC system operates properly through the complete sequence of operation (e.g., seasonal, occupied and unoccupied, warm up, etc.), for specified control sequences. Demonstrate proper control system response for abnormal conditions for which there is a specified system or controls response by simulating these conditions. Demonstrate that hardware interlocks and safety devices work as designed. Demonstrate that the control system performs the correct sequence of control.

3.3.6 Opposite Season Test

Repeat the performance verification test during an opposite season to the first performance verification test.

3.4 TRAINING

Provide a qualified instructor to conduct training courses for designated personnel in maintenance and operation of HVAC and control systems. Orientate training to the specific system being installed under the contract. Furnish audiovisual equipment and other training materials and supplies. A training day is defined as 8 hours of classroom or lab instruction, including two 15-minute breaks and excluding lunch time, Monday through Friday, during the daytime shift in effect at the training facility. For guidance, assume that the attendees have a high school education and are familiar with HVAC systems. Submit planned training schedule, agenda, and class materials to the Government at least 45 days prior to training.

3.4.1 Training Course Documentation

Training shall be based on the operation and maintenance manuals and control system training manual. Deliver manuals for each trainee with two additional sets for archiving at the project site. Include an agenda, defined objectives, and a detailed description of subject matter for each lesson.

3.4.2 Operator Training I

The first class shall be taught for a period of 5 consecutive training days at least 1 month prior to the scheduled performance verification test. The first course shall be taught in a Government-provided facility on base. Training shall be classroom instruction, but have hands-on operation of similar digital controllers. Maximum of 5 personnel shall attend the course. Upon completion of course, each student, using appropriate documentation, shall be able to perform elementary operations, with guidance, and describe general hardware and functionality of the system. Course shall include but not be limited to description of hardware and operation of the system.

3.4.3 Operator Training II

The second course shall be taught in the field, using the operating equipment at project sites for a total of 16 hours of instruction per student, in blocks of 4 hours. Maximum of 5 personnel shall attend the course. Include hands-on training under constant monitoring of instructor. Course content shall duplicate the Operator Training I course as applied to the installed system. Instructor shall determine the level of the password to be issued to each student before each session. Upon completion of the course, students shall be proficient in system operation. Prepare a written report describing the skill level of each student at the end of the course.

3.4.4 Operator Training III

The third course shall be taught in the field, at the project site, for a period of 3 training days no later than 6 months after completion of endurance test. Maximum of 5 personnel shall attend the course. Course shall be structured to address specific topics that the students need to discuss and to answer questions concerning operation of the system. Upon completion of the course, students shall be proficient in system operation and shall have no unanswered questions regarding operation of the installed system.

3.4.5 System Maintenance Training

Course shall be taught at the project site within one month after completion of endurance test for a period of 2 training days. Maximum of 5 personnel shall attend the course. Course shall include but not be limited to the following:

a. Physical layout for each piece of hardware

b. Troubleshooting and diagnostics procedures

c. Repair instructions

d. Preventive maintenance procedures and schedule

e. Calibration procedures

3.5 QUALIFIED SERVICE ORGANIZATION LIST

The qualified service organization list shall include names and telephone numbers of organizations qualified to service HVAC control systems.

3.6 COMMISSIONING

Commissioning of control systems is specified in the pre-field TAB engineering report described in Section 23 05 93 TESTING, ADJUSTING AND BALANCING.

3.7 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurements commonly agreed on by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

Products	Inch-Pound	Metric
a. Pneumatic Actuators: Operating Pressure	= 25 psig	= 172 kPa (gage)
b. Transmitters: Output Signal	= 3 to 15 psi	= 21 to 103 kPa
c. Thermostat: Minimum Ranges	= 55 to 90 degrees F	= 13 to 32 degrees C
d. Thermometers: Scales	= 9 inches	= 229 mm
e. Pressure Gages: Diameter	= 2 1/2 inches	= 65 mm
f. Compressed Air Storage Tank: Minimum Working Pressure	= 200 psig	= 1379 kPa (gage)

-- End of Section --

SECTION 23 11 25

FACILITY GAS PIPING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.1	(2000) Diaphragm-Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.3	(2000) Rotary-Type Gas Displacement Meters
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.1	(2010; Addenda A 2011; Addenda B 2012) Household Cooking Gas Appliances
ANSI Z21.15/CSA 9.1	(2009; Addenda A 2012, Addenda B 2013; R 2014) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
ANSI Z21.18/CSA 6.3	(2007; Addenda A 2010; Addenda B 2012; R 2013) Gas Appliance Pressure Regulators
ANSI Z21.21/CSA 6.5	(2005; Addenda A 2010; Addenda B 2011) Automatic Valves for Gas Appliances
ANSI Z21.24/CSA 6.10	(2006; R 2011) Connectors for Gas Appliances
ANSI Z21.41/CSA 6.9	(2014) Quick-Disconnect Devices for Use with Gas Fuel Appliances
ANSI Z21.69/CSA 6.16	(2009; Addenda A 2012; R 2014) Connectors for Movable Gas Appliances
ANSI Z21.78/CSA 6.20	(2010) Standard Specification for Combination Gas Controls for Gas Appliances
ANSI Z21.80/CSA 6.22	(2011; Addenda A 2012) Line Pressure Regulators

AMERICAN PETROLEUM INSTITUTE (API)

API 570	(2009, 3rd Ed) Piping Inspection Code:

	In-Service Inspection, Rating, Repair, and Alteration of Piping Systems
API RP 2009	(2002; R 2007; 7th Ed) Safe Welding, Cutting, and Hot Work Practices in Refineries, Gasoline Plants, and Petrochemical Plants
API Spec 15LR	(2001; R 2013) Specification for Low Pressure Fiberglass Line Pipe and Fittings
API Spec 5CT	(2011; Errata 2012) Specification for Casing and Tubing
API Spec 6D	(2014; Errata 1-2 2014; Errata 3 2015) Specification for Pipeline Valves
API Std 598	(2009) Valve Inspecting and Testing
API Std 607	(2010) Testing of Valves: Fire Test for Soft-Seated Quarter-Turn Valves

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-06	(2008) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding
AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems
ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.33	(2012) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to

	125 psi, Sizes NPS 1/2 - NPS 2
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.9	(2014) Building Services Piping
ASME B36.10M	(2004; R 2010) Standard for Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM 01.01	(2014) Steel - Piping, Tubing, Fittings
ASTM A105/A105M	(2014) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A513/A513M	(2014) Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
ASTM A666	(2010) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B210	(2012) Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B210M	(2012) Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes (Metric)
ASTM B241/B241M	(2012; E 2013) Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B280	(2013) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D2513	(2014; E 2014) Thermoplastic Gas Pressure

	Pipe, Tubing, and Fittings
ASTM D2517	(2006; R 2011) Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM F2015	(2000; R 2013) Standard Specification for Lap Joint Flange Pipe End Applications

CSA GROUP (CSA)

CGA 3.11-M88	(1988; R 2014) Lever Operated Pressure Lubricated Plug Type Gas Shut-Off Valves
CGA 3.16-M88	(1988; R 2014) Lever Operated Non-Lubricated Gas Shut-Off Valves
CGA 9.2-M88	(1988; R 2009) Manually Operated Shut-Off Valves for Gas Piping Systems

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-83	(2006) Class 3000 Steel Pipe Unions Socket Welding and Threaded
MSS SP-86	(2009; Errata 2011) Guidelines for Metric Data in Standards for Valves, Flanges, Fittings and Actuators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2015) National Fuel Gas Code
NFPA 58	(2014; TIA 13-1; TIA 13-2; Errata 13-1; TIA 13-3; Errata 14-2) Liquefied Petroleum Gas Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1541	(2009) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel socket-welding pipe Fittings

1.2 SYSTEM DESCRIPTION

The gas piping system includes natural gas piping and appurtenances from point of connection with supply system, as indicated, to gas operated equipment within the facility. Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein.

1.2.1 Gas Facility System and Equipment Operation

Include shop drawings showing piping layout, locations of system valves, gas line markers and cathodic protection system; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system drawings); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data package No. 4.

1.2.2 Gas Facility System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No.4.

1.2.3 Gas Facility Equipment Maintenance

Include identification of valves, shut-offs, disconnects, and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Gas Piping System; G

SD-03 Product Data

Pipe and Fittings; G
Gas equipment connectors; G
Gas Piping System; G
Pipe Coating Materials; G
Pressure regulators; G
Risers; G
Transition fittings; G
Valves; G
Valve box; G
Warning and identification tape; G

SD-06 Test Reports

Testing
Pressure Tests
Pressure Tests for Liquefied Petroleum Gas
Test With Gas

SD-07 Certificates

Welders procedures and qualifications
assigned number, letter, or symbol

SD-08 Manufacturer's Instructions

PE pipe and fittings; G
pipe coating materials; G

SD-10 Operation and Maintenance Data

Gas facility system and equipment operation; G
Gas facility system maintenance; G
Gas facility equipment maintenance; G

1.4 QUALITY ASSURANCE

Submit manufacturer's descriptive data and installation instructions for approval for compression-type mechanical joints used in joining dissimilar materials and for insulating joints. Mark all valves, flanges and fittings in accordance with MSS SP-25.

1.4.1 Welding Qualifications

a. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators in accordance with API RP 2009, ASME BPVC SEC IX, and ASME B31.9. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.9. Notify the Contracting Officer at least 24 hours in advance of tests, and perform at the work site if practicable.

b. Submit a certified copy of welders procedures and qualifications metal and PE in conformance with ASME B31.9 for each welder and welding operator. Submit the assigned number, letter, or symbol that will be used in identifying the work of each welder to the Contracting Officer. Weld all structural members in accordance with Section 05 05 23 WELDING, STRUCTURAL, and in conformance with AWS A5.8/A5.8M, and AWS WHB-2.9.

1.4.2 Jointing Thermoplastic and Fiberglass Piping

Perform all jointing of piping using qualified joiners and qualified procedures in accordance with AGA XR0603. Furnish the Contracting Officer with a copy of qualified procedures and list of and identification symbols of qualified joiners. Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart, including all PE pipe and fittings.

1.4.3 Shop Drawings

Submit drawings for complete Gas Piping System, within 30 days of contract award, showing location, size and all branches of pipeline; location of all required shutoff valves; and instructions necessary for the installation of gas equipment connectors and supports.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe and fittings ends during transportation or storage to minimize dirt and moisture entry. Do not subject piping to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Submit catalog data and installation instructions for pipe, valves, all related system components, pipe coating materials and application procedures. Conform to NFPA 54 and with requirements specified herein. Provide supply piping to appliances or equipment at least as large as the inlets thereof.

2.2 GAS PIPING SYSTEM AND FITTINGS

2.2.1 Steel Pipe, Joints, and Fittings

Provide steel pipe conforming to ASME B36.10M; and malleable-iron threaded fittings conforming to MSS SP-86 (ASME B16.1 and ASME B16.3) or KS B 1531. Provide steel pipe flanges and flanged fittings, including bolts, nuts, and bolt pattern in accordance with ASME B16.5 and ASTM A105/A105M. Provide wrought steel buttwelding fittings conforming to ASME B16.9 or KS B 1541. Provide socket welding and threaded forged steel fittings conforming to MSS SP-83 (ASME B16.11) or KS B 1542 and ASTM A181/A181M, Class 60.

2.2.2 Aluminum Alloy Pipe and Tubing, Joints, and Fittings

Provide aluminum alloy pipe conforming to ASTM B241/B241M, except that alloy 5456 is not allowed. Mark the ends of each length of pipe indicating it conforms to NFPA 54 . Thread, flange, braze, or weld pipe joints. Provide aluminum alloy tubing conforming to ASTM B210M (ASTM B210), Type A or B, or ASTM B241/B241M, Type A or equivalent, with joints made up with gas tubing fittings recommended by the tubing manufacturer.

2.2.3 Copper Tubing, Joints and Fittings

Provide copper tubing conforming to ASTM B88M (ASTM B88), Type K or L, or ASTM B280, with tubing joints made up with tubing fittings recommended by the tubing manufacturer. Provide copper and copper alloy press fittings, with sealing elements of Hydrogenated Nitrile Butadiene Rubber (HNBR), factory installed, or an alternative supplied by the fitting manufacturer.

2.2.4 Steel Tubing, Joints and Fittings

Provide steel tubing conforming to ASTM 01.01, and ASTM A513/A513M, with tubing joints made up with gas tubing fittings recommended by the tubing manufacturer.

2.2.5 Thermoplastic Pipe, Tubing, Joints, and Fittings

Provide thermoplastic pipe, tubing, casing and joints and fittings conforming to ASTM D2513 and API Spec 5CT.

2.2.6 Fiberglass Pipe, Joints, and Fittings

Provide fiberglass piping systems conforming to ASTM D2517 and API Spec 15LR.

2.2.7 Sealants for Steel Pipe Threaded Joints

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE, Class 20 or less. For taping, use tetrafluoroethylene tape conforming to UL FLAMMABLE & COMBUSTIBLE.

2.2.8 Warning and Identification

Provide pipe flow markings, warning and identification tape, and metal tags as required.

2.2.9 Flange Gaskets

Provide gaskets of nonasbestos compressed material in accordance with ASME B16.21, 1.6 mm (1/16 inch) thickness, full face or self-centering flat ring type, containing aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR) suitable for a maximum 316 degrees C (600 degree F) service, to be used for hydrocarbon service.

2.2.10 Pipe Threads

Provide pipe threads conforming to ASME B1.20.2M (ASME B1.20.1).

2.2.11 Escutcheons

Provide chromium-plated steel or chromium-plated brass escutcheons, either one piece or split pattern, held in place by internal spring tension or set screw.

2.2.12 Gas Transition Fittings

a. Provide steel to plastic (PE) designed for steel-to-plastic with tapping tee or sleeve conforming to AGA XR0603 requirements for transitions fittings. Coat or wrap exposed steel pipe with heavy plastic coating.

b. Plastic to Plastic: Manufacturer's standard bolt-on (PVC to PE) plastic tapping saddle tee, UL listed for gas service, rated for 690 kPa (gage) (100 psig), and O-ring seals. Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support conforming to ASTM A666, O-ring seals, and rated for 1035 kPa (gage) (150 psig) gas service. Manufacturer's standard fused tapping (PE-to-PE) tee assembly with shut-off feature.

c. Provide lever operated pressure lubricated plug type gas shut-off valve conforming to CGA 3.11-M88. Provide lever operated non-lubricated gas shut-off valves conforming to CGA 3.16-M88. Provide manually operated shut-off valve conforming to CGA 9.2-M88.

2.2.13 Insulating Pipe Joints

2.2.13.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.13.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.13.3 Flanged Pipe Joints

Provide joints for flanged pipe consisting of full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts, and insulating washers for flange nuts. Provide lap joint flange pipe ends conforming to ASTM F2015.

2.2.14 Flexible Connectors

a. Provide flexible connectors for connecting gas utilization equipment to building gas piping conforming to ANSI Z21.24/CSA 6.10 or ANSI Z21.41/CSA 6.9 for quick disconnect devices, and flexible connectors for movable food service equipment conforming to ANSI Z21.69/CSA 6.16. Provide combination gas controls for gas appliances conforming to ANSI Z21.78/CSA 6.20.

b. Do not install the flexible connector through the appliance cabinet face. Provide rigid metallic pipe and fittings to extend the final connection beyond the cabinet, except when appliance is provided with an external connection point.

2.3 VALVES

Provide lockable shutoff or service isolation valves as indicated in the drawings conforming to the following:

2.3.1 Valves 50 mm (2 Inches) and Smaller

Provide valves 50 mm (2 inches) and smaller conforming to ASME B16.33 of materials and manufacture compatible with system materials used. Provide manually operated household cooking gas appliance valves conforming to ANSI Z21.1 and ANSI Z21.15/CSA 9.1.

2.3.2 Valves 65 mm (2-1/2 Inches) and Larger

Provide valves 65 mm (2-1/2 inches) and larger of carbon steel conforming to API Spec 6D, Class 150.

2.4 RISERS

Provide manufacturer's standard riser, transition from plastic to steel pipe with 0.18 to 0.30 mm (7 to 12 mil) thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide remote bolt-on or bracket or wall-mounted riser supports as indicated on the drawings.

2.5 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58 and MSS SP-69.

2.6 METERING, REGULATORS AND SHUTOFF VALVES

Provide diaphragm-type meter conforming to AGA ANSI B109.1 or rotary-type displacement meter conforming to AGA ANSI B109.3 as required by local gas utility supplier, including valve box conforming to NFPA 54. Provide pressure gauges and attachments conforming to ASME B40.100. Provide regulators conforming to ANSI Z21.18/CSA 6.3 for appliances, ANSI Z21.78/CSA 6.20 for combination gas controls for gas appliances, and ANSI Z21.80/CSA 6.22 for line pressure regulators. Provide shutoff valves conforming to ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves and ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances.

2.7 SEISMIC PROVISIONS

Provide earthquake automatic gas shutoff valve conforming to ASCE 25-06, SMACNA 1981, and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The valve may be either pendulum or ball construction with remote, pneumatic, electronic, or electric actuator.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy or areas of conflict before performing the work.

3.2 EXCAVATION AND BACKFILLING

Provide required excavation, backfilling, and compaction as specified in Section 31 00 00 EARTHWORK.

3.3 GAS PIPING SYSTEM

Provide a gas piping system from the point of delivery, defined as the outlet of the meter set assembly, service regulator, or shutoff valve, as specified in Section 33 51 15 NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION, and as indicated on drawings to the connections to each gas utilization device.

3.3.1 Protection and Cleaning of Materials and Components

Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system.

3.3.2 Workmanship and Defects

Piping, tubing and fittings shall be clear and free of cutting burrs and defects in structure or threading and shall be thoroughly brushed and chip-and scale-blown. Repair of defects in piping, tubing or fittings is not allowed; replace defective items when found.

3.4 PROTECTIVE COVERING

3.4.1 Underground Metallic Pipe

Protect buried metallic piping from corrosion with protective coatings as specified in Section 33 51 15 NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION. When dissimilar metals are joined underground, use gastight insulating fittings.

3.4.2 Aboveground Metallic Piping Systems

3.4.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer. Solvent clean surfaces that have not been shop primed . Mechanically clean surfaces that contain loose rust, loose mill scale, and other foreign substances by power wire brushing or commercial sand blasted conforming to SSPC SP 6/NACE No.3 and prime with ferrous metal primer or vinyl type wash coat. Finish primed surfaces with two coats of exterior oil paint or vinyl paint.

3.4.2.2 Nonferrous Surfaces

Except for aluminum alloy pipe, do not paint nonferrous surfaces. Paint surfaces of aluminum alloy pipe and fittings to protect against external corrosion where they contact masonry, plaster, insulation, or are subject to repeated wettings by such liquids as water, detergents or sewage. Solvent-clean the surfaces and treat with vinyl type wash coat. Apply a first coat of aluminum paint and a second coat of alkyd gloss enamel or silicone alkyd copolymer enamel.

3.5 INSTALLATION

Install the gas system in conformance with the manufacturer's recommendations and applicable provisions of NFPA 54, AGA XR0603, and as indicated. Perform all pipe cutting without damage to the pipe, with an approved type of mechanical cutter, unless otherwise authorized. Use wheel cutters where practicable. On steel pipe 150 mm (6 inches) and larger, an approved gas cutting and beveling machine may be used. Cut thermoplastic and fiberglass pipe in accordance with AGA XR0603.

3.5.1 Metallic Piping Installation

Bury underground piping a minimum of 450 mm (18 inches) below grade. Make changes in direction of piping with fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either tees or forged branch outlet fittings. Provide branch outlet fittings which are forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Do not use aluminum alloy pipe in exterior locations or underground.

3.5.2 Metallic Tubing Installation

Install metallic tubing using gas tubing fittings approved by the tubing manufacturer. Make branch connections with tees. Prepare all tubing ends with tools designed for that purpose. Do not use aluminum alloy tubing in exterior locations or underground.

3.5.3 Thermoplastic and Fiberglass Piping, Tubing, and Fittings

Installation of thermoplastic and fiberglass piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 450 mm (18 inches) below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated.

3.5.4 Connections Between Metallic and Plastic Piping

Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

3.5.5 Piping Buried Under Buildings

Run underground piping installed beneath buildings in a steel pipe casing protected from corrosion with protective coatings as specified in Section 23 11 25 FACILITY GAS PIPING. Extend casing at least 100 mm (4 inches) outside the building, and provide the pipe with spacers and end bushings to seal at both ends to prevent the entrance of water and/or the escape of gas. Extend a vent line from the annular space above grade outside to a point where gas will not be a hazard, and terminate in a rain/insect-resistant fitting.

3.5.6 Concealed Piping in Buildings

Do not use combinations of fittings (unions, tubing fittings, running threads, right- and left-hand couplings, bushings, and swing joints) to conceal piping within buildings.

3.5.6.1 Piping in Partitions

Locate concealed piping in hollow, rather than solid, partitions. Protect tubing passing through walls or partitions against physical damage both during and after construction, and provide appropriate safety markings and labels..

3.5.6.2 Piping in Floors

Lay piping in solid floors except where embedment in concrete is indicated in channels suitably covered to permit access to the piping with minimum damage to the building. Surround piping embedded in concrete by a minimum of 40 mm (1-1/2 inches) of concrete and do not allow physical contact with other metallic items such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quickset additives or cinder aggregate.

3.5.7 Aboveground Piping

Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than 150 mm (6 inches) from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.

3.5.8 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Make final connections to kitchen ranges using flexible connectors not less than 1.02 m (40 inch) long, to afford access to coupling and to permit movement of equipment for cleaning. Flexible connectors may be used for final connections to residential dryers. Flexible connectors may be used for final connections to gas utilization equipment. In addition to cautions listed in instructions required by ANSI standards for flexible connectors, insure that flexible connectors do not pass through equipment cabinet. Provide accessible gas shutoff valve and coupling for each gas equipment item.

3.5.9 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads in conformance with ASCE 25-06 , as specified in UFC 3-310-04, and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, and as shown on the drawings.

3.6 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.

3.6.1 Threaded Metallic Joints

Provide threaded joints in metallic pipe with tapered threads evenly cut and made with UL approved graphite joint sealing compound for gas service or tetrafluoroethylene tape applied to the male threads only. Threaded joints up to 40 mm (1-1/2 inches) in diameter may be made with approved tetrafluoroethylene tape. Threaded joints up to 50 mm (2 inches) in diameter may be made with approved joint sealing compound. After cutting and before threading, ream pipe and remove all burrs. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.6.2 Welded Metallic Joints

Conform beveling, alignment, heat treatment, and inspection of welds to NFPA 54. Remove weld defects and make repairs to the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect and store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating.

3.6.3 Thermoplastic and Fiberglass Joints

a. Thermoplastic and Fiberglass: Conform jointing procedures to AGA XR0603. Do not make joints with solvent cement or heat of fusion between different kinds of plastics.

b. PE Fusion Welding Inspection: Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect, in conformance with API 570, 100 percent of all joints and re-inspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.6.4 Flared Metallic Tubing Joints

Make flared joints in metallic tubing with special tools recommended by the tubing manufacturer. Use flared joints only in systems constructed from nonferrous pipe and tubing, when experience or tests have demonstrated that the joint is suitable for the conditions, and when adequate provisions are made in the design to prevent separation of the joints. Do not use metallic ball sleeve compression-type tubing fittings for tubing joints.

3.6.5 Solder or Brazed Joints

Make all joints in metallic tubing and fittings with materials and procedures recommended by the tubing supplier. Braze joints with material having a melting point above 538 degrees C (1000 degrees F), containing no phosphorous.

3.6.6 Joining Thermoplastic or Fiberglass to Metallic Piping or Tubing

When compression type mechanical joints are used, provide gasket material in the fittings compatible with the plastic piping and with the gas in the system. Use an internal tubular rigid stiffener in conjunction with the fitting, flush with end of the pipe or tubing, extending at least to the outside end of the compression fitting when installed. Remove all rough or sharp edges from stiffener. Do not force fit stiffener in the plastic. Split tubular stiffeners are not allowed.

3.6.7 Press Connections

Make press connections in accordance with manufacturer's installation instructions using tools approved by the manufacturer. Fully insert the tubing into the fitting and then mark at the shoulder of the fitting. Check the fitting alignment against the mark on the tubing to assure the tubing is fully inserted before the joint is pressed.

3.7 PIPE SLEEVES

Provide pipes passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Do not install sleeves in structural members except where indicated or approved. Make all rectangular and square openings as detailed. Extend each sleeve through its respective wall, floor or roof, and cut flush with each surface, except in mechanical room floors not located on grade where clamping flanges or riser pipe clamps are used. Extend sleeves in mechanical room floors above grade at least 100 mm (4 inches) above finish floor. Unless otherwise indicated, use sleeves large enough to provide a minimum clearance of 6.4 mm (1/4 inch) all around the pipe. Provide steel pipe for sleeves in bearing walls, waterproofing membrane floors, and wet areas . Provide sleeves in nonbearing walls, floors, or ceilings of steel pipe, galvanized sheet metal with lock-type longitudinal seam, or moisture-resistant fiber or plastic. For penetrations of fire walls, fire partitions and floors which are not on grade, seal the annular space between the pipe and sleeve with fire-stopping material and sealant that meet the requirement of Section 07 84 00 FIRESTOPPING.

3.8 PIPES PENETRATING WATERPROOFING MEMBRANES

Install pipes penetrating waterproofing membranes as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.9 FIRE SEAL

Fire seal all penetrations of fire rated partitions, walls and floors in accordance with Section 07 84 00 FIRESTOPPING.

3.10 ESCUTCHEONS

Provide escutcheons for all finished surfaces where gas piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms.

3.11 SPECIAL REQUIREMENTS

Provide drips, grading of the lines, freeze protection, and branch outlet locations as shown and conforming to the requirements of NFPA 54 and NFPA 58.

3.12 BUILDING STRUCTURE

Do not weaken any building structure by the installation of any gas piping. Do not cut or notch beams, joists or columns. Attach piping supports to metal decking. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the

Contracting Officer.

3.13 PIPING SYSTEM SUPPORTS

Support gas piping systems in buildings with pipe hooks, metal pipe straps, bands or hangers suitable for the size of piping or tubing. Do not support any gas piping system by other piping. Conform spacing of supports in gas piping and tubing installations to the requirements of NFPA 54 and NFPA 58. Conform the selection and application of supports in gas piping and tubing installations to the requirements of MSS SP-69. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members is not to exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Rigidly connect the clips or clamps to the common base member. Provide a clearance of 3.2 mm (1/8 inch) between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

3.14 ELECTRICAL BONDING AND GROUNDING

Provide a gas piping system within the building which is electrically continuous and bonded to a grounding electrode as required by NFPA 70.

3.15 SHUTOFF VALVE

Install the main gas shutoff valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled.

3.16 TESTING

Submit test reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, blow out the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Complete testing before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install bulkheads, anchorage and bracing suitably designed to resist test pressures if necessary, and as directed and or approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.16.1 Pressure Tests

Submit test reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Before appliances are connected, test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 21 kPa (3 pounds) gauge for a period of not less than 10 minutes as specified in NFPA 54 and NFPA 58 without showing any drop in pressure. Do not use Oxygen for test. Measure pressure with a mercury manometer, slope gauge, or an equivalent device calibrated to be read in increments of not greater than 1 kPa (0.1 pound).

Isolate the source of pressure before the pressure tests are made.

3.17.1 Pressure Tests for Liquefied Petroleum Gas

Pressure test system as described above. When appliances are connected to the piping system, use fuel gas for testing appliances to withstand a pressure of not less than 2.5 kPa nor more than 3.5 kPa (10.0 inches nor more than 14.0 inches water column) for a period of not less than 10 minutes without showing any drop in pressure. Measure pressure with a water manometer or an equivalent device calibrated to be read in increments of not greater than 20 Pa. Isolate the source of pressure before the pressure tests are made.

3.16.2 Test With Gas

Before turning on gas under pressure into any piping, close all openings from which gas can escape. Immediately after turning on the gas, check the piping system for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. Conform all testing to the requirements of NFPA 54 and NFPA 58. If leakage is recorded, shut off the gas supply, repair the leak , and repeat the tests until all leaks have been stopped.

3.16.3 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. Do not purge piping into the combustion chamber of an appliance. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 and NFPA 58 are followed.

3.16.4 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.17 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS, conforming to ASME A13.1.

-- End of Section --

SECTION 23 23 00

REFRIGERANT PIPING
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 710 I-P	(2009) Performance Rating of Liquid-Line Driers
AHRI 711	(2009) Performance Rating of Liquid-Line Driers
AHRI 720	(2002) Refrigerant Access Valves and Hose Connectors
ANSI/AHRI 750	(2007) Thermostatic Refrigerant Expansion Valves
ANSI/AHRI 760	(2007) Performance Rating of Solenoid Valves for Use With Volatile Refrigerants

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 17	(2008) Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components
ASME B31.9	(2014) Building Services Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A334/A334M	(2004a; R 2010) Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by

	the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	(2013) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B813	(2010) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(2007) Taper Pipe Threads
KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1541	(2009) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel socket-welding pipe Fittings
KS B 1543	(2009) Steel plate butt-welding pipe fittings

KS B 5305	(2008) Bourdon Tube Pressure Gauges
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes
KS D 6704	(2001) Soft Solder
KS D 8319	(2003) Silver Brazing Filler Metals

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System; G

SD-03 Product Data

Refrigerant Piping System
Spare Parts
Qualifications; G
Refrigerant Piping Tests; G
Demonstrations; G
Verification of Dimensions

SD-06 Test Reports

Refrigerant Piping Tests

SD-07 Certificates

Service Organization; G

SD-10 Operation and Maintenance Data

Maintenance
Operation and Maintenance Manuals

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit one hard copy & one digital copy (.pdf - text searchable) of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations. Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL and 05 12 00 STRUCTURAL STEEL. Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.

1.3.2 Contract Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

1.5 MAINTENANCE

1.5.1 General

Submit Data Package 2 plus operation and maintenance data complying with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.5.2 Extra Materials

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than one month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

b. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

c. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

d. Exposed equipment moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

e. Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Include in the data manufacturer's recommended installation instructions and procedures. Provide data for the following components as a minimum:

a. Piping and Fittings
b. Valves
c. Piping Accessories
d. Pipe Hangers, Inserts, and Supports

2.2 ELECTRICAL WORK

Electrical equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Field wiring shall be in accordance with manufacturer's instructions. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.3 REFRIGERANT PIPING SYSTEM

Refrigerant piping, valves, fittings, and accessories shall be in accordance with ANSI/ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories shall be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service shall be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant. Submit drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Piping layouts which identify all valves and fittings.

b. Plans and elevations which identify clearances required for maintenance and operation.

2.4 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

2.4.1 Steel Pipe

Steel pipe for refrigerant service shall conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B or KS D 3562. Type F pipe shall not be used.

2.4.1.1 Welded Fittings and Connections

Butt-welded fittings shall conform to ASME B16.9 or KS B 1541 and KS B 1543. Socket-welded fittings shall conform to ASME B16.11 or KS B 1542. Welded fittings shall be identified with the appropriate grade and marking symbol. Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9.

2.4.1.2 Threaded Fittings and Connections

Threaded fitting shall conform to ASME B16.3 or KS B 1531. Threaded valves and pipe connections shall conform to ASME B1.20.2M (ASME B1.20.1) or KS B 0222.

2.4.1.3 Flanged Fittings and Connections

Flanges shall conform to ASME B16.5, Class 150. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.59 mm (1/16 inch) thickness, full face or self-centering flat ring type. Gaskets shall contain aramid fibers bonded with styrene butadeine rubber (SBR) or nitrile butadeine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.5. Bolts shall be high or intermediate strength material conforming to ASTM A193/A193M.

2.4.2 Steel Tubing

Tubing shall be cold-rolled, electric-forged, welded-steel in accordance with ASTM A334/A334M, Grade 1. Joints and fittings shall be socket type provided by the steel tubing manufacturer.

2.4.3 Copper Tubing

Copper tubing shall conform to ASTM B280 or KS D 5301 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm (1-3/8 inches). Joints shall be brazed except that joints on lines 22 mm (7/8 inch)and smaller may be flared. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62. Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75/B75M. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings shall not be allowed for brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

2.4.4 Solder

Solder shall conform to ASTM B32, grade Sb5 or KS D 6704, tin-antimony alloy for service pressures up to 1034 kPa (150 psig). Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

2.4.5 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux or KS D 8319, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.5 VALVES

Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 25 mm (1 inch) and smaller shall have brazed or socket welded connections. Valves larger than 25 mm (1 inch) shall have tongue-and-groove flanged or butt welded end connections. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve body. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.5.1 Refrigerant Stop Valves

Valve shall be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing shall be replaceable under line pressure. Valve shall be provided with a handwheel or wrench operator and a seal cap. Valve shall be the straight or angle pattern design as indicated.

2.5.2 Check Valves

Valve shall be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve shall be provided with resilient seat.

2.5.3 Liquid Solenoid Valves

Valves shall comply with ANSI/AHRI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2760 kPa (400 psi) and a maximum operating pressure differential of at least 1375 kPa (200 psi) at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.5.4 Expansion Valves

Valve shall conform to ANSI/AHRI 750 and ASHRAE 17. Valve shall be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 degree C (2 degrees F) of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicted or for constant evaporator loads.

2.5.5 Safety Relief Valves

Valve shall be the two-way type, unless indicated otherwise. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.5.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degree C (2 degrees F) change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.5.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall be in accordance with AHRI 720.

2.6 PIPING ACCESSORIES

2.6.1 Filter Driers

Driers shall conform to AHRI 711 (AHRI 710 I-P). Sizes 15 mm (5/8 inch) and larger shall be the full flow, replaceable core type. Sizes 13 mm (1/2 inch) and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10.3 MPa (1,500 psi).

2.6.2 Sight Glass and Liquid Level Indicator

2.6.2.1 Assembly and Components

Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

2.6.2.2 Gauge Glass

Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.6.2.3 Bull's-Eye and Inline Sight Glass Reflex Lens

Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlit viewing shall be provided.

2.6.2.4 Moisture Indicator

Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.6.3 Vibration Dampeners

Dampeners shall be of the all-metallic bellows and woven-wire type.

2.6.4 Flexible Pipe Connectors

Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C (300 degrees F). Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.6.5 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.6.6 Pressure and Vacuum Gauges

Gauges shall conform to ASME B40.100 or KS B 5305 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.6.7 Temperature Gauges

Temperature gauges shall be the industrial duty type and be provided for the required temperature range. Gauges shall have Celsius scale in 1 degree (Fahrenheit scale in 2 degrees) graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1.5 m (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1.5 to 2.1 m (5 to 7 feet) above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 2.1 m (7 feet) above the finished floor.

2.6.7.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.6.7.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.6.7.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.6.7.4 Thermal Well

Thermal well shall be identical size, 13 or 19 mm (1/2 or 3/4 inch) NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 13 mm (1/2 inch) NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm (1 inch).

2.6.8 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58 and MSS SP-69.

2.6.9 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.7.2 Factory Applied Insulation

Refrigerant suction lines between the cooler and each compressor, cold gas inlet connections to gas cooled motors, and refrigerant pumps and exposed chilled water lines on absorption chillers shall be insulated with not less than 19 mm (3/4 inch) thick unicellular plastic foam. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform a verification of dimensions in the field. Submit a letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found before performing any work.

3.2 INSTALLATION

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.2.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.2.2 Functional Requirements

Piping shall be installed 4 mm/m (1/2 inch/10 feet) of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

3.2.3 Fittings and End Connections

3.2.3.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.2.3.2 Brazed Connections

Brazing shall be performed in accordance with AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and not be sprung or forced.

3.2.3.3 Welded Connections

Welded joints in steel refrigerant piping shall be fusion-welded. Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.2.3.4 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.2.3.5 Flanged Connections

When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled.

3.2.4 Valves

3.2.4.1 General

Refrigerant stop valves shall be installed on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Stop valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensable gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

3.2.4.2 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 54 mm (2-1/8 inches) in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 54 mm (2-1/8 inches). The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall be installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

3.2.4.3 Valve Identification

Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 34 mm (1-3/8 inch) diameter, or equivalent dimension, and securely attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14 gauge (14 gauge) annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.2.5 Vibration Dampers

Vibration damper shall be provided in the suction and discharge lines on spring mounted compressors. Vibration dampers shall be installed parallel with the shaft of the compressor and shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.2.6 Strainers

Strainers shall be provided immediately ahead of solenoid valves and expansion devices. Strainers may be an integral part of an expansion valve.

3.2.7 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed. Dryers shall be installed such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.8 Sight Glass

A moisture indicating sight glass shall be installed in all refrigerant circuits downstream of all filter dryers and where indicated. Site glasses shall be full line size.

3.2.9 Discharge Line Oil Separator

Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

3.2.10 Accumulator

Accumulators shall be provided in the suction line to each compressor.

3.2.11 Flexible Pipe Connectors

Connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required.

3.2.12 Temperature Gauges

Temperature gauges shall be located specifically on, but not limited to the following: the sensing element of each automatic temperature control device where a thermometer is not an integral part thereof, the liquid line leaving a receiver, and the suction line at each evaporator or liquid cooler. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm (1 inch).

3.2.13 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.2.13.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.2.13.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.2.13.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.13.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.2.13.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C (60 degrees F) or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C (60 degrees F). A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.2.13.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg (50 pounds) shall have the excess hanger loads suspended from panel points.

3.2.13.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m (15 feet) not more than 2.4 m (8 feet) from end of risers, and at vent terminations.

3.2.13.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.2.13.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.2.13.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches), or by an amount adequate for the insulation, whichever is greater.

3.2.13.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.2.13.12 Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified under UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and as shown on the drawings. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.2.13.13 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.2.14 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m (5 feet) on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 600 mm (2 feet) on each side of the joint.

3.2.15 Pipe Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.2.16 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 1.0 mm (20 gauge). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm (1/2 inch) depth. Sleeves shall not be installed in structural members.

3.2.16.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed as indicated with not less than 100 mm (4 inches) of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 100 mm (4 inches) of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.16.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 6 mm (1/4 inch) all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

3.2.16.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 5.17 kg/sq. m (17 ounce) copper sleeve, or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 inches) above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.2.16.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.2.16.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.2.17 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.2.18 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.19 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.19.1 Color Coding

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.19.2 Color Coding Scheme

A color coding scheme for locating hidden piping shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.2.20 Identification Tags

Provide identification tags made of brass, engraved laminated plastic or engraved anodized aluminum indicating service and item number on all valves and dampers. Tags shall be 35 mm (1-3/8 inch) minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.3 CLEANING AND ADJUSTING

Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture, contaminated refrigerant, or any foreign matter shall be considered contaminated systems. Restoring contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, shall be performed using currently approved refrigerant and refrigeration manufacturer's procedures. Restoring contaminated systems shall be at no additional cost to the Government as determined by the Contracting Officer. Water shall not be used in any procedure or test.

3.4 TRAINING COURSE

a. Submit a schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training. Conduct a training course for members of the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

b. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

c. Submit one hard copy & one digital copy (.pdf - text searchable) of the operation manual listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. Manual shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

d. Submit one hard copy & one digital (.pdf - text searchable) copy of the maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manual shall include piping layouts and simplified wiring and control diagrams of the system as installed.

3.5 REFRIGERANT PIPING TESTS

After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Submit a schedule, at least 2 weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit one hard copy & one digital copy (.pdf - text searchable) of the tests report documenting all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

3.5.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.5.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 55 degrees C (minus 70 degree F) dew point and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 69 kPa (10 psi) with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ANSI/ASHRAE 15 & 34 with a maximum test pressure 25 percent greater. Pressure above 690 KPa (100 psig) shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure will be recorded along with the ambient temperature to which the system is exposed. A correction factor of 2 kPa (0.3 psi) will be allowed for each degree C (F) change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, then the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing shall not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.5.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C (35 degrees F). No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, then the system shall be evacuated again down to 300 micrometers and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure continues to rise, check the system for leaks, repair as required, and repeat the evacuation procedure. During evacuation, pressures shall be recorded by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.5.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

3.5.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

3.5.6 Contractor's Responsibility

At all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for 4 members of the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 23 52 00

HEATING BOILERS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 801	(2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.13/CSA 4.9	(2014; Errata 2014) Gas-Fired Low Pressure Steam and Hot Water Boilers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012; Errata 2013; INT 1 2014) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2011) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2010) Specification for Brazing Procedure and Performance Qualification

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint

	Pressure Fittings
ASME B16.20	(2012) Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral Wound, and Jacketed
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2010) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2012) Control and Safety Devices for Automatically Fired Boilers
ASME PTC 10	(1997; R 2014) Performance Test Code on Compressors and Exhausters

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2014) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A167	(2011) Standard Specification for

	Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A515/A515M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B813	(2010) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2002; R 2010) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless

	Copper Water Tube (Metric)
ASTM C155	(1997; R 2013) Standard Specification for Insulating Firebrick
ASTM C27	(1998; R 2008) Fireclay and High-Alumina Refractory Brick
ASTM C34	(2013) Structural Clay Load-Bearing Wall Tile
ASTM C401	(2012) Alumina and Alumina-Silicate Castable Refractories
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D596	(2001; R 2011) Reporting Results of Analysis of Water
ASTM F1097	(1991; R 2012) Mortar, Refractory (High-Temperature, Air-Setting)
ASTM F1139	(1988; R 2010) Steam Traps and Drains
ASTM F876	(2013a) Crosslinked Polyethylene (PEX) Tubing

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2010) Copper Tube Handbook

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2011) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

HI-004	(1995) Radiant Floor Heating
HYI-005	(2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and

	Flared Ends
MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2014) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2013) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 31	(2011) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2015) National Fuel Gas Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 85	(2011; Errata 2011; AMD 1 2014) Boiler and Combustion Systems Hazards Code

UNDERWRITERS LABORATORIES (UL)

UL 1738	(2010; Reprint Nov 2014) Venting Systems for Gas-Burning Appliances, Categories II, III and IV
UL 296	(2003; Reprint Sep 2013) Oil Burners
UL 726	(1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies
UL 795	(2011; Reprint Nov 2013) Standard for Commercial-Industrial Gas Heating Equipment
UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(2007) Taper Pipe Threads
KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1536	(2009) Bellows Type Expansion Pipe Joints
KS B 1541	(2009) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel socket-welding pipe Fittings
KS B 1543	(2009) Steel plate butt-welding pipe fittings
KS B 1545	(2006) Copper and Copper Alloy Fittings for Flared Copper Tubes
KS B 2301	(2009) Bronze Gate, Globe, Angle and Check Valves
KS B 2333	(2012) Butterfly Valves for Water Works
KS B 5305	(2008) Bourdon Tube Pressure Gauges
KS B 6205	(2008) Land Boilers-Heat Balancing
KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 4307	(2009) Cast-Iron Soil Pipes and Fittings
KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes
KS D 5578	(2009) Pipe Fittings of Copper and Copper Alloys

KS D 6704	(2001) Soft Solder
KS D 8319	(2003) Silver Brazing Filler Metals

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Materials and Equipment
Spare Parts
Water Treatment System
Boiler Water Treatment
Heating System Tests
Fuel System Tests
Unit Heaters
Welding
Qualifications
Field Instructions
Tests

SD-06 Test Reports

Heating System Tests
Fuel System Tests
Water Treatment Testing

SD-07 Certificates

Bolts
Continuous Emissions Monitoring
Energy Star

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions
Water Treatment System

1.3 QUALITY ASSURANCE

WELDING: Submit a copy of qualified welding procedures and a list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations. Boilers and piping shall be welded and brazed in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests, and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL. Welding and nondestructive testing procedures for piping are specified in Section 40 05 13.96 WELDING PROCESS PIPING.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. Submit Detail Drawings consisting of equipment layout including installation details and electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function as a unit and to show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Submit manufacturer's catalog data included with the detail drawings for the following:

a. Radiant floor heating system including tubing, joints, and manifold for radiant floor heating systems.

b. Data showing model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements. Data shall include manufacturer's written installation instructions and manufacturer's recommendations for operation and maintenance clearances for the following:

1) Boilers
2) Unit Heaters
3) Fuel Burning Equipment
4) Combustion Control Equipment

5) Pumps
6) Fittings and Accessories
7) Fuel Oil Storage System
8) Water Treatment System

2.1.2 Asbestos Prohibition

Asbestos and asbestos-containing products will not be allowed.

2.1.3 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. Also, display an ENERGY STAR label as applicable. Each pressure vessel shall have an approved ASME stamp.

2.1.4 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Sections 05 50 13 MISCELLANEOUS METAL FABRICATIONS and 05 51 33 METAL LADDERS.

2.2 BOILERS

Each boiler shall have the output capacity in kilowatts (kW) (British thermal units per hour (Btuh)) as indicated when fired with the specified fuels. The boiler shall be furnished complete with the oil, gas, or combination oil/gas burning equipment, boiler fittings and trim, automatic controls, forced or induced draft fan, natural draft/atmospheric burner, electrical wiring, insulation, piping connections, and protective jacket. The boiler shall be completely assembled and tested at the manufacturer's plant. Boiler auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork. However, the boiler safety devices shall not be sized for a 10 percent excess capacity. The boiler and its accessories shall be designed and installed to permit ready accessibility for operation, maintenance, and service. Boilers shall be designed, constructed, and equipped in accordance with ASME BPVC SEC IV. Each boiler shall be of the fire tube, watertube, cast iron, or condensing type and designed for water or steam service as specified herein. The boiler capacity shall be based on the ratings shown in HYI-005 or as certified by the American Boiler Manufacturers Association, or American Gas Association. Boiler efficiency and capacity certification testing performed in accordance with BTS-2000 or KS B 6205 for Gas-Fired Low-Pressure Steam and Hot Water Boilers by Korea Energy Management Corporation (KEMCO) will be accepted.

2.2.1 Fire tube Boiler

Boiler shall be self-contained, multipass, packaged type, complete with all accessories, mounted on a structural steel base. When the boilers are operating at maximum output, the heat input rates shall not be greater than

21 Kw/square meter (6,700 Btu/hr per square ft) of fireside heating surface.

2.2.2 Watertube Boiler

The boiler shall be a standard, finned, or bent or flexible type of water tube boiler, as indicated in contract drawings. Boiler shall be self-contained, packaged type, complete with all accessories, mounted on a structural steel base. The boiler heating surface area for bent or flexible tube boilers shall be at least 0.03 square meters/kW (4 square feet/boiler horse power). The heat input rate for finned tube steam boiler or hot water generator shall not be greater than 12,000 Btu/hour based on internal heating area. Bent or flexible tube boilers shall be provided with single or multiple downcomers for circulation without the need for exterior pumping. The tubes for bent or flexible tube boilers shall be designed for replacement without requiring welding or rolling of tubes. Any special tools required for bent or flexible tube removal or installation shall be provided with the boiler.

2.2.3 Cast Iron Boiler

Boiler shall be of the rectangular, sectional type, self-contained, packaged type, complete with accessories, mounted on a structural steel base. Cast iron sections shall be free of leaks under all operating conditions. Access shall be provided to permit cleaning of internal tube surfaces.

2.2.4 Condensing Boiler

Each boiler shall be a self-contained packaged type, complete with accessories, mounted on a structural steel base or a steel base which is integral to the boiler shell. Each boiler shall conform to the commercial design used by the manufacturer and shall permit free thermal expansion without placing undue stress on any part of the boiler. Each boiler which experiences the formation of condensate within the flue gas shall be specifically designed for condensing application. Each boiler shall withstand the corrosive effects of condensate for each part which may be in contact with the condensate at all possible operating conditions. Each boiler shall be provided with a separate air intake, exhaust, and condensate drain. Each boiler shall be designed to withstand the water temperature differentials anticipated at the required operating conditions without experiencing any damage due to thermal shock.

2.2.5 Modular Configuration

Modular boilers shall be of the cast iron and condensing type. Modular boilers shall have the capability of independent operation. Upon failure of any module, the remaining modules shall be capable of operating at their designed capacity. The size of the individual modules shall be as indicated.

2.2.6 Hot Water Heating Boilers

The hot water heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. The boiler design conditions shall be as follows:

a. Boiler design pressure 200 kPa (30 psig) or as indicated in the contract drawings.

b. Operating pressure at boiler outlet 200 kPa (30 psig).

c. Hot water temperature 80 degrees C (180 degrees F).

d. Temperature differential between boiler discharge and system return 10 degrees C (50 degrees F).

e. Water pressure drop 70 kPa (10 psig) or as indicated in the contract drawings.

f. Outdoor ambient air temperature 32.2 degrees C (90 degrees F) (max), -6.6 degrees C (20 degrees F) (min).

g. Site elevation 0 m (0 feet).h. Maximum continuous capacity in kW (Btuh) as indicated in contract drawings.

i. Rated capacity in kW (Btuh) as indicated in contract drawings.

j. Maximum exhaust stack temperature in degrees C (degrees F) as indicated in contract drawings.

h. Boilers with a capacity less than 90 kW (300,000 Btuh) shall have an Annual Fuel Utilization Efficiency of at least 85 percent. Gas fired boilers with a capacity of greater than or equal to 90 kW (300,000 Btuh) shall have a thermal efficiency of at least 80 percent when fired at the maximum and minimum ratings allowed by the controls. Oil fired boilers with a capacity of greater than or equal to 90 kW (300,000 Btuh) shall have a thermal efficiency of at least 83 percent when fired at the maximum and minimum ratings allowed by the controls. Condensing boilers shall have an Annual Fuel Utilization Efficiency of at least 90 percent.

2.2.7 Steam Heating Boilers

The boiler shall be provided with a water column with gauge glass and fittings including water column and gauge glass drain valves of the straight through type. The steam heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. Design conditions shall be as follows:

a. Boiler design pressure 200 kPa (30 psig).

b. Operating pressure at boiler outlet 100 kPa (15 psig).

c. Steam temperature 120 degrees C (250 degrees F).

d. Feed water temperature 93 degrees C (200 degrees F).

e. Outdoor ambient air temperature 32.2 degrees C (90 degrees F) (max), -6.6 degrees C (20 degrees F) (min).

f. Site elevation 0 m (0 feet).g. Maximum continuous capacity in kg (pounds) of steam per hour as indicated in contract drawings.

h. Rated capacity in kg (pounds) of steam per hour as indicated in contract drawings .

i. Maximum exhaust stack temperature degrees C (degrees F) as indicated in contract drawings.

g. Boilers with a capacity less than 90 kW (300,000 Btuh) shall have an Annual Fuel Utilization Efficiency of at least 85 percent. Gas fired boilers with a capacity of greater than or equal to 90 kW (300,000 Btuh) and less than or equal to 733 kW (2,500,000 Btuh) shall have a thermal efficiency of at least 79 percent. Gas fired boilers with a capacity greater than 733 kW (2,500,000 Btuh) shall have a thermal efficiency of at least 80 percent. Oil fired boilers with a capacity greater than or equal to 90 kW (300,000 Btuh) shall have a thermal efficiency of at least 83 percent when fired at the maximum and minimum ratings allowed by the controls.

2.3 FUEL BURNING EQUIPMENT

Boiler shall be designed to burn gas, oil, or combination gas and oil. Each boiler shall comply with ROK National, provincial, and local emission regulations.

2.3.1 Burners

2.3.1.1 Gas and Combination Gas-Oil Fired Burners and Controls

Burners shall be UL approved mechanical draft burners with all air necessary for combustion supplied by a blower where the operation is coordinated with the burner or natural draft/atmospheric burners. Burner shall be provided complete with fuel supply system in conformance with the following safety codes or standards:

a. Gas-fired units with inputs greater than 0.117 MW (400,000 Btuh) per combustion chamber shall conform to UL 795. Gas fired units less than 3.66 MW (12,500,000 Btuh) input shall conform to ANSI Z21.13/CSA 4.9. Single and multiple burner gas-fired units greater than or equal to 3.66 MW (12,500,000 Btuh) input shall conform to NFPA 85.

b. Combination gas and oil-fired units shall conform to UL 296. Combination gas and oil-fired units less than 3.66 MW (12,500,000 Btuh) input shall conform to ASME CSD-1. Single and multiple burner combination gas and oil-fired units equal to or greater than 3.66 MW (12,500,000 Btuh) input shall conform to NFPA 85.

2.3.1.2 Oil-Fired Burners and Controls

Oil-fired burners and controls for oil-fired units firing No. 2 oil shall be atomizing, forced-draft type in conformance with UL 726. Oil-fired units less than 3.66 MW (12,500,000 Btuh) input shall conform to ASME CSD-1. Oil-fired units greater than or equal to 3.66 MW (12,500,000 Btuh) input shall conform to NFPA 85.

2.3.1.3 Steam or Air Atomizer

Steam or air atomizer shall be of the inside mix type utilizing steam or air mixing with the oil inside the nozzle. No moving parts shall be required within the atomizer assembly. Unit shall be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when supplied with steam or air at a maximum pressure of 100 kPa (15 psig). Capacity of unit shall be adjustable. Unit shall be furnished with a blowout valve so that steam or air may be blown through the oil passages to clear them of any accumulation. A diffuser designed to stabilize the flame shall be mounted near the furnace end of the atomizer in such a position that oil will not strike it.

2.3.1.4 Mechanical pressure atomizer

Mechanical pressure atomizer shall operate solely by the use of oil pressure and shall have no moving parts within the atomizer. Unit shall be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when furnished with oil at a constant pressure as indicated in contract drawings. A constant volume of oil shall be supplied to the atomizer. Variable capacity shall be obtained by adjusting control valve. A diffuser provided to stabilize the flame shall be mounted near the furnace end of the atomizer, but in such a position that oil will not strike it.

2.3.2 Draft Fans

Fans conforming to AMCA 801 forced-draft and induced-draft shall be furnished as an integral part of boiler design. Fans shall be centrifugal with backward-curved blades or radial-tip blades or axial flow type. Each fan shall be sized for output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner, leakages, temperature, and elevation corrections for worst ambient conditions, all at full combustion to meet net-rated output at normal firing conditions, plus an overall excess air volume of 10 percent against a 20 percent static overpressure. Noise levels for fans shall not exceed 85 decibels in any octave band at a 0.914 m (3 foot) station. Forced draft fan bearings shall be air cooled. Induced-draft fans shall be designed for handling hot flue gas at the maximum outlet temperature in the boiler. Induced draft fan housings shall be provided with drain holes to accommodate the drainage of condensation. Induced draft fan bearings shall be air-cooled or water-cooled. Induced draft fan scroll sheets and rotor blades shall have protective liners.

2.3.2.1 Draft Fan Control

Forced-draft centrifugal fans shall have inlet vane controls or shall have variable speed control where indicated. Inlet vanes shall be suitable for use with combustion control equipment. Induced-draft centrifugal fans shall have outlet dampers and shall have variable speed control. Induced-draft fans shall have inlet vane controls. Axial propeller fans shall have variable propeller pitch control.

2.3.2.2 Draft Fan Drives

Fans shall be driven by electric motors. Electric motor shall be drip proof, totally enclosed nonventilated, totally enclosed fan cooled, or totally enclosed fan-cooled, suitable for installation in a Class II, Division 1, Group F, hazardous location conforming to NFPA 70. Motor starter shall be magnetic across-the-line or reduced voltage start type with general purpose, weather-resistant, watertight, dust-tight, or explosion-proof enclosure as indicated in contract drawings and shall be furnished with four auxiliary interlock contacts.

2.3.3 Draft Damper

Boilers shall be provided with manual or automatic dampers, draft hoods, or barometric dampers as recommended by the boiler manufacturer to maintain proper draft in the boiler. Draft damper shall be provided in a convenient and accessible location in the flue gas outlet from the boiler. Automatic damper shall be arranged for automatic operation by means of a damper regulator, furnace draft regulator, or damper motor.

2.3.4 Ductwork

Air ducts connecting the forced-draft fan units with the plenum chamber shall be designed to convey air with a minimum of pressure loss due to friction. Ductwork shall be galvanized sheet metal conforming to ASTM A653/A653M. Ducts shall be straight and smooth on the inside with laps made in direction of air flow. Ducts shall have cross-break with enough center height to assure rigidity in the duct section, shall be angle iron braced, and shall be completely free of vibration. Access and inspection doors shall be provided as indicated and required, with a minimum of one in each section between dampers or items of equipment. Ducts shall be constructed with long radius elbows having a centerline radius 1-1/2 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints shall be substantially airtight and shall have adequate strength for the service, with 38 x 38 x 3 mm (1-1/2 x 1-1/2 x 1/8 inch) angles used where required for strength or rigidity. Duct wall thickness shall be 16 gauge (1.5 mm (0.0598 inch)) for ducts 1500 mm (60 inches) or less and 12 gauge (2.66 mm (0.1046 inch)) for ducts larger than 1500 mm (60 inches) in maximum dimension. Additional ductwork shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.4 COMBUSTION CONTROL EQUIPMENT

Combustion control equipment shall be provided as a system by a single manufacturer. Field installed automatic combustion control system shall be installed in accordance with the manufacturer's recommendations and under the direct supervision of a representative of the control manufacturer. The boiler water temperature shall be controlled by a water temperature controller. The boiler pressure shall be controlled by a steam pressure controller. The equipment shall operate either electrically or pneumatically. On multiple boiler installations, each boiler unit shall have a completely independent system of controls responding to the load and to a plant master controller. If recording instruments are provided, a 1 year supply of ink and 400 blank charts for each recorder shall be furnished.

2.4.1 Pneumatic Controls

If pneumatic operation is provided, a regenerant desiccant air dryer unit shall be provided. Boiler shall shut down on loss of control air pressure. Pneumatic control systems shall conform to CAGI B19.1. Air filter regulator sets shall be installed at each control valve and transmitter in the system. The master air filter regulator set on the control panel shall be the dual type where one side can be cleaned and repaired while the other is operating. Exterior control air piping and devices shall be protected from freezing.

2.4.1.1 Air Compressor Unit

The air compressor unit shall be electric-motor driven, polytetrafluoroethylene or carbon ring type automatic air compressor. The compressor unit shall be sized to run not more than 60 percent of the time when all controls are in service. The air compressor unit shall be complete with necessary accessories including automatic pressure control equipment, relief valves, check valves, air filters, moisture traps, and a receiver with ample capacity for emergency operation of the controls for 15 minutes after compressor shutdown. Compressor speed shall not exceed 900 rpm. Motor speed shall not exceed 1750 rpm. The compressor air intake shall be provided with a low drop type air suction filter/silencer suitable for outdoor installation.

2.4.1.2 Air Receiver

The air receiver shall be constructed in accordance with ASME BPVC SEC VIII D1for unfired pressure vessels for 1379 kPa (200 psi) working pressure, and shall be equipped with inlet and outlet connections, valved drain connection, minimum 150 mm (6 inch) dial pressure gauge, pop safety valves, and regulator connections.

2.4.2 Electrical controls

Electrical control devices shall be rated at 120 or 24 volts, as indicated in contract drawings, and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.3 Water Temperature Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The thermostatic element shall be inserted in a separable socket installed in the upper part of the boiler near the water outlet or in the boiler return piping. Fixed position (on-off) and three position (high-low-off) controller shall operate on a 5.56 degree C (10 degree F) differential over an adjustable temperature range of approximately 60 to 104.4 degrees C (140 to 220 degrees F). Modulating controllers shall control the fuel burning equipment to maintain set boiler water temperature within 2 percent. Controller shall be furnished with necessary equipment to automatically adjust the setting to suit the outside weather conditions. The outside air reset controller shall be operated in such a manner that the operating temperatures required by the boiler manufacturer are not compromised.

2.4.4 Steam Pressure Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The sensing elements of the steam controller shall be in direct contact with the steam. Fixed position (on-off) and three position (high-low-off) type controllers shall operate on a 6.9 kPa (1 pound) differential over a pressure range of 0 to 103.4 kPa (0 to 15 psig). Modulating controllers shall automatically maintain, within 2 percent, the desired steam pressure by regulating the burner.

2.4.5 Boiler Plant Master Controller

A boiler plant master controller, sensitive to a temperature transmitter in the return water header for the boiler or a steam pressure transmitter in the boiler steam discharge header shall be furnished to provide anticipatory signals to all boiler controllers. Boiler controllers shall react to anticipatory signals from the plant master controller as necessary in response to the boiler temperature or pressure indication to maintain the preset temperature or pressure. An automatic-manual switch shall be provided to allow the sequence of boiler loading to be varied to distribute equal firing time on all boilers in the plant. The plant master controller shall load the boilers one at a time as the plant load increases.

2.4.6 Boiler Combustion Controls and Positioners

a. Gas or Combination gas-oil fired boiler units shall be provided with fixed rate (on-off), three position (high-low-off), or modulating combustion controls with gas pilot or spark ignition. Modulating controls shall be provided with a means for manually controlling the firing rate.

b. Oil fired boiler units shall be provided with on-off, high-low-off, or modulating combustion controls with direct electric spark ignition system, spark ignited , or natural gas or liquefied petroleum gas pilot. Modulating controls shall be provided with a means for manually controlling the firing rate.

c. Modulating control function shall be accomplished using positioning type controls. Air flow ratio and fuel control valve shall be controlled by relative positions of operative levers on a jackshaft responding to a water temperature controller or steam pressure controller. Positioning type combustion control equipment shall include draft controls with synchronized fuel feed and combustion air supply controls, while and shall maintain the proper air/fuel ratio. The desired furnace draft shall be maintained within 0.25 mm (0.01 inch) of water column.

d. Fixed rate on-off or High-low-off controls for boilers with capacities up to 600 kW (2,000,000 Btuh) shall use a water temperature controller in a temperature well in direct contact with the water or steam pressure controller in direct contact with the steam.

2.4.7 Combustion Safety Controls and Equipment

Combustion safety controls and equipment shall be UL listed, microprocessor-based distributed process controller. The system shall include mounting hardware, wiring and cables, and associated equipment. The controller shall be mounted completely wired, programmed, debugged, and tested to perform all of its functions. The controller shall process the signals for complete control and monitoring of the boiler. This shall include maintaining boiler status, starting and stopping all control functions, sequencing control functions and signaling alarm conditions. The program shall be documented and include cross references in description of coils and contacts. Microprocessor shall be able to perform self diagnostics and contain a message center to provide operator with status and failure mode information. Controllers for each boiler shall be mounted on a separate, free standing panel adjacent to the boiler or for packaged boilers on the boiler supporting structure. Control systems and safety devices for automatically fired boilers shall conform to ASME CSD-1. Electrical combustion and safety controls shall be rated at 120 volts, single phase, 60 Hz and shall be connected as specified in

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. A 100 mm (4 inch) diameter alarm bell shall be provided and shall be located where indicated or directed. The alarm bell shall ring when the boiler is shut down by any safety control or interlock. Indicating lights shall be provided on the control panel. A red light shall indicate flame failure, and a green light shall indicate that the main fuel valve is open. The following shutdown conditions shall require a manual reset before the boiler can automatically recycle:

a. Flame failure.

b. Failure to establish pilot flame.

c. Failure to establish main flame.

d. Low-water and supplementary low-water cutoff, unless otherwise indicated on contract drawings.

e. High temperature or high pressure cutoff.

2.4.7.1 Low-water Cutoff

Low water cutoff shall be float actuated switch or electrically actuated probe type low-water cutoff. Float chamber shall be provided with a blow-down connection. Cutoff shall cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level. A safety shutdown due to low water shall require manual reset before operation can be resumed and shall prevent recycling of the burner. The cutoff shall be in strict accordance to the latest version of code, ASME CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

a. Feed water Regulator with Low-Water Cutoff: Regulator shall be an approved design sized for the application. A regulator shall be provided for each boiler. The feeder shall be so arranged that water will be fed to the boiler automatically when the water level in the boiler drops below a preset point and will actuate the alarm bell when the water level reaches the low danger point. The boiler feeder shall be arranged so that the burner and forced-draft fan will stop whenever the water level drops below a preset danger point. The boiler feeder shall be constructed so that the feed water valve and seat are isolated from the float chamber to prevent overheating of the feed water and precipitation of scale on either the valve or seat. Each float mechanism, valve, and seat shall be constructed of an approved, durable, corrosion-resistant steel alloy. Valve seats shall be removable and renewable. The regulator shall be equipped with a large, self-cleaning strainer. The drain valve on the regulator shall be the gate or other straight-through type.

b. Pump Controller with Low-Water Cutoff: Controller shall be a design approved by the boiler manufacturer. A pump controller shall be provided for each boiler which is used for space heating and process steam loads or long distribution lines. Pump controller shall control the operation of the burner, forced-draft fan, and pump. Pump controller and low-water cutoff shall have a float-operated mercury switch arranged to start and stop the pump at preset boiler water levels. If the water level in the boiler reaches the low danger point, a second mercury switch shall shut down the burner and actuate the alarm bell.

c. Supplementary Low-Water Cutoff: Supplementary low-water cutoff of the electrically operated probe or float activated type shall be provided in addition to the low-water cutoff required above on each boiler. Supplementary low-water cutoff shall be mounted directly in the boiler shell and shall be set below the low-water cutoff required above.

2.4.7.2 Water Flow Interlock

Hot water boiler limit controls shall be provided to include protection for low boiler water flow and high boiler water temperature. The limit controls shall be interlocked with the combustion control system to effect boiler alarm and shutdown. The controls shall not allow boiler startup unless hot water flow is proven.

2.5 PUMPS

2.5.1 Fuel Oil Pumping and Heating Sets

The integrated, shop-fabricated oil pumping and heating set shall be simplex or duplex and be UL approved. Two positive displacement oil meters shall be provided. One meter shall be located on the fuel supply line. The other meter shall be located on the fuel return line. Each set shall include an electric oil heater of adequate capacity to heat the specified fuel oil to ignition temperature at low boiler load until enough hot water or steam is generated to operate the heat exchanger. The electric heater shall be controlled by magnetic starter with a manually-operated On-Off switch in series with a thermostatic control. When oil temperature is raised to proper level and maintained by the hot water or steam heater, the electric heater shall be disconnected automatically by the thermostatic control. Fuel pumps shall be electric-motor-driven. A duplex or single filter/basket strainer system shall be installed ahead of the electric oil heater and final discharge filter/strainer system.

2.5.2 Hot Water and Boiler Circulating Pumps

Circulating pumps for hot water shall be electrically driven single-stage centrifugal type and have a capacity not less than indicated. Boiler circulating pumps shall be supported on a concrete foundation with a cast iron or structural steel base and shall be closed-coupled shaft or flexible-coupled shaft. The boiler circulating pumps shall be horizontal split case or vertical split case type. Hot water circulating pumps shall be supported on a concrete foundation with a cast iron or structural steel base or by the piping on which installed and shall have a closed-coupled or flexible-coupled shaft. The hot water circulating pumps shall be horizontal or vertical split case type. The pump shaft shall be constructed of corrosion-resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal, and the housing of close-grained cast iron. Pump seals shall be capable of withstanding 115 degrees C (240 degrees F) temperature without external cooling. The motor shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for the available electric service, and shall conform to the requirements of paragraph ELECTRICAL EQUIPMENT. Each pump suction and discharge connection shall be provided with a pressure gauge as specified. The boiler or hot water circulating pump discharge heater shall be provided with a flow or pressure switch. Flow switch unit shall be a self-contained swinging vane type to indicate fluid flow. Pressure switch unit shall be a self-contained snap action type to indicate fluid pressure. Switch shall be a SPDT with 120-volt, 15-ampere rating.

2.5.3 Condensate Pumping Unit

Each pump shall have a capacity not less than that indicated when discharging against the specified pressure. The minimum capacity of the tank shall be as indicated. The condensate pumping unit shall be the single, duplex, horizontal shaft, or vertical shaft type as indicated. The unit shall consist of one or two pumps with electric motor drive, and a single receiver, all mounted on a suitable cast-iron or steel base. The motor may be mounted on the top of the receiving tank. Pump shall be the centrifugal or turbine type, bronze-fitted throughout, with impellers of bronze or other approved corrosion-resisting metal. Pump shall be free from air binding when handling condensate of temperatures up to 93 degrees C (200 degrees F). Pump shall be directly connected to suitable drip-proof enclosed motors. Receiver shall be cast iron or not less than 4.75 mm (3/16 inch) thick black iron or steel and shall be provided with all the necessary reinforced threaded openings, including condensate return, vent, overflow, and pump suction connections. Inlet strainer shall be provided either integral in the tank or separate in the inlet line to the tank. Vent pipe shall be galvanized steel, and the fittings shall be galvanized malleable iron. Vent pipe shall be extended through the roof and shall be properly flashed. The pump, motor, and receiving tank may be mounted on a single base with the receiver piped to the pump suctions. A gate valve and check valve shall be provided in the discharge connection from each pump and a strainer and gate valve shall be provided in the suction line to each pump except where pumps are directly mounted on top of the receiver.

2.5.3.1 Controls for Space Heating Steam Loads Only

An enclosed float switch complete with float mechanisms shall be installed in the head of the receiver. Each condensate pump shall be controlled by a float switch which shall automatically start the motor when the water in the receiving tank reaches the high level and stop the motor when the water reaches the low level. The motors shall be provided with magnetic across-the-line starters equipped with general-purpose enclosures and three-position, "Manual-Off-Automatic" selector switches in the cover. Automatic alternator shall be provided for duplex units.

2.5.3.2 Space Heating and Steam Loads or Distribution Lines

The condensate pump shall be provided with an approved float-actuated valve or water feeder in the cold-water makeup connection either external to or integral with the receiver. Where a de-aerating feed water heater is not included, the condensate pumping unit shall be controlled automatically by a pump controller with low-water cutout on each boiler. The pump controller and low-water cutout shall have two float-operated mercury switches arranged to start and stop the condensate pump at preset boiler water levels. One switch shall control the operation of the condensate pump by starting the pump when the water in the boiler reaches a preset low level and by stopping the pump when the water in the boiler rises to a preset high level. The second switch shall ring an alarm bell and simultaneously shut down the burner. Relays shall be provided if necessary. A minimum 100 mm (4 inch) alarm bell with bell-ringing transformer shall be installed where directed. A gate valve and a check valve or a stop-check (nonreturn) valve shall be installed in the feed line between the boiler and the pump adjacent to the boiler connection.

The condensate pump motor shall be provided with a magnetic, across-the-line starter equipped with thermal-overload protection conforming to the requirements of paragraph ELECTRICAL EQUIPMENT. Where two or more boilers are provided, a pump controller and low-water cutout shall be installed at the normal waterline of each boiler. An automatic feed valve shall be installed in the feed line to each boiler. When any boiler requires water, the pump controller shall open the feed valve by actuating an end switch which, in turn, operates the condensate pump. When the normal water level is restored, the pump controller shall close the feed valve, and the end switch of the valve shall stop the condensate pump.

2.5.3.3 Rating and Testing

The pump manufacturer shall submit a certified test report covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

2.5.4 Vacuum Pumping Unit

The vacuum pumping unit shall be a combination air removal and condensate return unit consisting of pumps, electric motors, and other functioning parts in duplicate and a single receiving tank as indicated. Two interconnected single units will be acceptable in place of a duplex unit. The unit shall be arranged for automatic operation. Where duplicate pumps are used, one pump shall serve as a standby. Where it is standard with the manufacturer, separate pumps may be used for air removal and condensate return if both pumps are mounted on a common receiver. The receiver shall be constructed of cast iron, or of not less than 4.75 mm (3/16 inch) thick black iron or steel. The pumping unit shall be bronze fitted throughout with bronze shafts or with shafts protected by bronze sleeves. Pumps, motors, and receiver shall be mounted on a single base and provision shall be made for catching the drip from the stuffing boxes. Accessories shall consist of a compound gauge, a pressure gauge inlet strainer, thermometer, water level gauge with stopcocks, adjustable vacuum relief valve, air discharge and condensate discharge check valves, and companion flanges for all flanged connections. The discharge line from each pump shall be provided with a nonslam check valve and a globe valve. Each motor shall have a drip-proof type enclosure. Fully automatic controls shall be provided for each pump motor. Controls shall consist of a float in the receiving tank, a float switch, an adjustable vacuum switch, an automatic, magnetic, across-the-line type starter with general-purpose enclosure, and a three-position selector switch in the cover. The selector switch shall provide for "Automatic," "Float," "Vacuum," or "Automatic," "Float," and "Continuous" operation of the pump.

2.6 COLD WATER CONNECTIONS

Connections shall be provided which includes consecutively in line a strainer, reduced pressure principle backflow preventers, and water pressure regulator in that order in the direction of the flow. The reduced pressure principle backflow preventers shall be provided as indicated and in compliance with Section 22 00 00 PLUMBING, GENERAL PURPOSE. Cold water fill connections shall be made to the water supply system as indicated. Necessary pipe, fittings, and valves required for water connections between the boiler and cold water main shall be provided as shown. The pressure regulating valve shall be of a type that will not stick or allow pressure to build up on the low side. The valve shall be set to maintain a terminal pressure of approximately 35 kPa (5 psi) in excess of the static head on the system and shall operate within a 15 kPa (2 psi) tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

2.7 RADIATORS AND CONVECTORS

Radiators, convectors and associated equipment shall be in accordance with Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS .

2.8 RADIANT FLOOR HEATING SYSTEMS

The radiant floor heating system shall include all piping, manifolds, valves, pumps, expansion tank, pressure relief valves, and controls to provide a complete and operational heating system.

2.8.1 Tubing

The tubing material shall comply with ASTM F876. The piping shall be provided with a factory applied oxygen barrier with a diffusion rate that does not exceed 0.1 grams per cubic meter per day. The piping shall be rated at 689 kPa (100 psi) and 82.5 degrees C (180 degrees F).

2.8.2 Joints

The manifold manufacturer shall be consulted to determine the proper joint for connection of tubing to the manifold. The joints required to connect the tubing to the manifold shall be compression type fittings using crimp rings, a combination of inserts and O-rings, gripper type fittings using a retainer ring and O-rings, or as otherwise recommended by the manifold and tubing manufacturer.

2.8.3 Manifold

The design and construction of the manifold shall be compatible with the tubing manufacture's requirements. The piping manifold material shall be compatible with the piping material. The manifold shall be capable of providing the number of circuits as indicated on the drawings. The manifold shall be suitable for an operating pressure of 689 kPa (100 psi) and 82.5 degrees C (180 degrees F). Balancing valves shall be provided for each circuit. Isolation valves shall be provided for each supply and return connection. Each manifold shall be provided with an air vent. The manifold shall allow for the measurement of temperature for each circuit. The manifold shall be provided with all required mounting hardware.

2.9 UNIT HEATERS

Heaters shall be as specified below, and shall have a heating capacity not in excess of 125 percent of the capacity indicated. Noise level of each unit heater for areas noted shall not exceed the criteria indicated.

2.9.1 Propeller Fan Heaters

Heaters shall be designed for suspension and arranged for horizontal or vertical discharge of air as indicated. Casings shall be not less than 0.912 mm (20 gauge) black steel and finished with lacquer or enamel. Suitable stationary or rotating air deflectors shall be provided to assure proper air and heat penetration capacity at floor level based on established design temperature. Suspension from heating pipes will not be permitted. Fans for vertical discharge type heaters shall operate at speeds not in excess of 1,200 rpm, except that units with 84.4 MJ (80,000 Btu) output capacity or less may operate at speeds up to 1,800 rpm. Horizontal discharge type unit heaters shall have discharge or face velocities not in excess of the following:

Unit Capacity, Liters per Second	Face Velocity, Meters per Second
Up to 472	4.06
473	4.57
1417	5.08

Unit Capacity, cfm	Face Velocity, fpm
Up to 1,000	800
1,001 to 3,000	900
3,001 and over	1,000

2.9.2 Centrifugal Fan Heaters

Heaters shall be arranged for floor or ceiling mounting as indicated. Heating elements and fans shall be housed in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Cabinets shall be constructed of not lighter than 1.27 mm (18 gauge) black steel. Each unit heater shall be provided with a means of diffusing and distributing the air. Fans shall be mounted on a common shaft, with one fan to each air outlet. Fan shaft shall be equipped with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater shall be the same size.

2.9.3 Heating Elements

Heating coils and radiating fins shall be of suitable nonferrous alloy with threaded or brazed fittings at each end for connecting to external piping. The heating elements shall be free to expand or contract without developing leaks and shall be properly pitched for drainage. The elements shall be tested under a hydrostatic pressure of 1.38 MPa (200 psig) and a certified report of the test shall be submitted to the Contracting Officer. Heating coils shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM for types indicated. Coils shall be suitable for use with water up to 121 degrees C (250 degrees F).

2.9.4 Motors

Motors shall be provided with NEMA 250 general purpose enclosure. Motors and motor controls shall otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.9.5 Motor Switches

Motors shall be provided with manual selection switches with "Off," and "Automatic" positions and shall be equipped with thermal overload protection.

2.9.6 Controls

Controls shall be provided as specified in Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

2.10 HEATING AND VENTILATING UNITS

Heating and ventilating units and associated equipment shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.11 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.12 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.12.1 Soot Blowers

Where indicated, each boiler shall be provided with soot blowers using compressed air or steam as the blowing medium. The soot blower system shall be the automatic sequencing and intermittent puff type. The soot blower units shall be sequenced automatically using successive steps by their controller, each step involving no more than a 70 kPa (10 psi) drop in air pressure at the receiver. After one unit is operated in successive steps through its cycle, the controller shall shift the operation to the second soot blower unit, and so on, until all units on that boiler have been operated, after which the controller shall be shut down automatically by the sequence controls. The soot blower heads shall have elements of suitable material for the highest temperatures encountered in the boiler. The sequence timer shall have provision for manual selection of the soot blower units to be used. Soot blower system for oil fired boilers shall conform to NFPA 85.

2.12.1.1 Air Compressor Unit

The air compressor unit shall conform to ASME PTC 10 except as specified otherwise. Compressor speed shall not exceed 900 rpm. Motor speed shall not exceed 1750 rpm. The service air requirements shall be as indicated with receivers sized as indicated. The units shall be suitable for heavy-duty service (soot blowing). The compressors shall be simplex type, single-stage, double-acting, with water-jacketed cylinder, fitted with intake and discharge valves of the lightweight feather, disc or plate type, and shall be provided with necessary controls, water-cooled aftercooler, moisture separator, drive, receiver, relief valves, and cooling water controls as required. The compressor air intake shall be provided with an air suction filter/silencer suitable for outdoor installation. The filter shall have a collection efficiency of 99 percent of particles larger than 10 microns. The filter body and media shall withstand a pressure of 850 kPa (125 psi). The aftercooler shall be the shell-and-tube type designed for air flow through the tubes with steel shell internal baffle plates. The cooling capacity of the after cooler shall be sized for the total capacity of the compressor. The moisture separator shall be provided with an automatic water discharge trap and level gauge. Cooling water controls for regulating compressor cylinder water temperature and after-cooler water temperature shall be thermostatic valve type and shall be installed with a three-valve bypass in the water outlet lines ahead of open sight drain funnels. The compressor shall be equipped with adjustable, pressure type unloader controls suitable for continuous compressor operation.

2.12.1.2 Air Receiver

The air receiver shall be a vertical type constructed in accordance with ASME BPVC SEC VIII D1 for unfired pressure vessels for 1379 kPa (200 psi) working pressure, and shall be equipped with flanged inlet and outlet connections, valved drain connection, minimum 150 mm (6 inch) dial pressure gauge, pop safety valves, and regulator connections.

2.12.2 Continuous Emissions Monitoring

a. Continuous Emissions Monitoring System (CEMS) equipment shall be provided as a system by a single manufacturer. A CEMS, meeting the requirements of applicable national, provincial, and local regulations, shall be provided for each boiler in accordance with manufacturer's recommendations and under the direct supervision of the CEMS equipment manufacturer. Before acceptance of the installation, the Contracting Officer shall be furnished a written test report which provides documentation that the CEMS equipment passed factory and field certification test required by federal, state, and local regulations. Submit written certification by the boiler manufacturer that each boiler furnished complies with Federal, state, and local regulations for emissions. The certification shall also include a description of applicable emission regulations. If any boiler is exempt from the emission regulations, the certification shall indicate the reason for the exemption.

b. The reported data shall include sulfur dioxide (SO2), oxides of nitrogen (NOX), carbon dioxide (CO2) and particulate matter (PM) and other information required by national, provincial, and local regulations. SO2 reporting shall be based on analyzer measurement or fuel flow and percent sulfur calculation. Nitrous oxides, carbon dioxide and particulate matter reporting shall be based on analyzers.

c. The CEMS equipment shall include the central processing unit, printer, hard disk drive, and floppy disk drive. The floppy disk drive shall function as a recorder. The manufacturer shall provide the software to generate the required reports in a format acceptable to the Federal, state and local regulatory agencies. The operator interface to the CEMS equipment shall be via CRT screen.

2.12.2.1 Gaseous Emission Monitors

Extractive or in situ gaseous monitors shall be provided. A combination of extractive and in situ monitors is not acceptable. Gas monitors shall include automatic calibration checks. An alarm horn and annunciator shall be provided to alarm when any monitor parameter is out of range or a gaseous monitor malfunctions. The surfaces that are exposed to the corrosive gas of the boiler shall be constructed of noncorrosive materials such as 316 SS, teflon or hastelloy.

a. In situ monitor shall be mounted on the ductwork at the location recommended by the manufacturer. The situ system shall not be affected by the presence of particulate matter in the flue gas.

b. Extractive systems shall be wet, dry, or diluted. Analyzing equipment for the extractive system shall be located in a walk-in cabinet. The equipment shall be arranged to provide access for maintenance. Extractive system sampling between the probes and the analyzers shall be heat traced to maintain the temperature recommended by the manufacturer when the ambient temperature is 43.3 degrees C (110 degrees F). Probes shall be mounted on the ductwork at the location shown on the plans or as recommended by the manufacturer.

2.12.2.2 Flue Gas Flow Monitor

Flue gas flow monitor shall utilize the pitot tube principle to measure the flow. The probe shall be an across-the-duct-average pitot tube and shall be designed and located to obtain representative measurement. Differential pressure transmitters shall be used to sense the difference between the static and total pressure of the flowing gas steam. Calibrations shall be stable. Lines shall be arranged to prevent collection of condensate. A purge system shall be provided as required to keep the pitot pressure taps clear.

2.12.2.3 Particulate Matter Monitor

Particulate matter (opacity) monitor based on the principle of transmissometry shall be provided. The transmissometer shall include automatic simulation of zero opacity and upscale check of calibration while the boiler is in service without dismounting the unit. The calibration check shall include analyzer internal circuitry and electronic circuitry. An alarm horn and annunciator shall be provided to annunciate excess opacity and any system malfunction. Units shall be provided with fans to keep the sending and receiving lenses pressurized and blown clean at all times.

2.12.2.4 Wiring

The CEMS equipment shall be provided with plug-in prefabricated cable for interconnection between components. Power supply to the equipment shall be 2-wire, 120 volt nominal or less, 60 Hz, with one side grounded. Electrical devices shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.12.3 Tankless Water Heater

A seamless copper immersion type tankless water heater of the specified capacity shall be installed in the boiler. The heater shall be equipped with an approved water-tempering valve which shall be set to supply hot water at approximately 65 degrees C (150 degrees F). Instead of the immersion type coil, an approved external shell and tube type or plate type heat exchanger may be installed as specified in Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS.

2.12.4 Conventional Breeching and Stacks

2.12.4.1 Breeching

Each boiler shall be connected to the stack or flue by breeching constructed of black steel sheets not less than 1.2 mm (0.0478 inch) thick or less than thickness of stack, whichever is larger. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The clear distance between any portion of the breeching surface and any combustible material shall not be less than that specified in NFPA 211. Joints and seams shall be securely fastened and made airtight. Suitable hinged and gasketed cleanouts shall be provided, which will permit cleaning the entire smoke connection without dismantling. Flexible-type expansion joints shall be provided as required and shall not require packing.

2.12.4.2 Stacks

Individual stub stacks shall extend above the roof to the heights indicated. Individual stub stacks shall be 6 m (20 feet) in height when assembled on the boiler and measured from the ground line. Stack section shall be sheet steel having a thickness of not less than 2.47 mm (0.0972 inch). Prefabricated double wall stacks system shall extend above the roof to the height indicated. The stacks shall be 6 m (20 feet) in height when assembled on the boiler and measured from the ground line. The inner stack shall be 304 stainless steel or 316 stainless steel having a thickness of not less than 0.89 mm (0.035 inch). The outer stack shall be sheet steel having a thickness of not less than 0.635 mm (0.025 inch). A method of maintaining concentricity between the inner and outer stacks shall be incorporated. The joints between the stack sections shall be sealed to prevent flue gas leakage. A 7.92 mm (0.3125 inch) diameter hole shall be provided in the stack not greater than 150 mm (6 inches) from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each stack shall be provided complete with rain hood. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.12.5 Direct Vents

Direct venting shall be used for condensing type boilers. Both the air intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer. A separate combustion air intake vent and exhaust vent shall be provided for each boiler.

2.12.5.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent shall be suitable for the temperature at the boiler combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.12.5.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel conforming to UL 1738 and the boiler manufacturer's recommendations. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The exhaust vent shall be suitable for the maximum anticipated boiler exhaust temperature and shall withstand the corrosive effects of the condensate. A 8 mm (0.3125 inch) diameter hole shall be provided in the stack not greater than 152 mm (6 inches) from the boiler flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.12.6 Expansion Tank

The hot water pressurization system shall include a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank. The sizes shall be as indicated. The expansion tank shall be welded steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 850 kPa (125 psi) and precharged to the minimum operating pressure. The tank's air chamber shall be fitted with an air charging valve and pressure gauge. The tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The tank shall have lifting rings and a drain connection. All components shall be suitable for a maximum operating temperature of 120 degrees C (250 degrees F).

2.12.7 Air Separator

External air separation tank shall be steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa (125 psi). The minimum capacity of the air separation tank shall be as indicated.

2.12.8 Filters

Filters shall conform to ASHRAE 52.2.

2.12.9 Foundation (Setting) Materials

2.12.9.1 Firebrick

Firebrick shall be ASTM C27 class as recommended by boiler manufacturer.

2.12.9.2 Tile

Tile shall be ASTM C34, Grade LBX.

2.12.9.3 Insulating Brick

Insulating brick shall comply with ASTM C155.

2.12.9.4 Refractory Mortar

Refractory mortar shall comply with ASTM F1097.

2.12.9.5 Castable Refractories

Castable refractories shall be ASTM C401. The minimum modulus of rupture for transverse strength shall be not less than 4136 kPa (600 psi) after being heat soaked for 5 hours or more at a temperature in excess of 1371 degrees C (2500 degrees F).

2.12.10 Steel Sheets

2.12.10.1 Galvanized Steel

Galvanized steel shall be ASTM A653/A653M or KS D 3506.

2.12.10.2 Uncoated Steel

Uncoated steel shall be composition, condition, and finish best suited to the intended use.

2.12.11 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.20, full face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

2.12.12 Steel Pipe and Fittings

2.12.12.1 Steel Pipe

Steel pipe shall be ASTM A53/A53M, Type E or S, Grade A or B, or KS D 3562, black steel, standard weight.

2.12.12.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.12.12.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer 's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M. Submit written certification by the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

2.12.12.4 Welded Fittings

Welded fittings shall conform to ASTM A234/A234M with WPA marking. Buttwelded fittings shall conform to ASME B16.9, KS B 1541, or KS B 1543, and socket-welded fittings shall conform to ASME B16.11 or KS B 1542.

2.12.12.5 Cast-Iron Fittings

Fittings shall be ASME B16.4, Class 125 or KS D 4307, type required to match connecting piping.

2.12.12.6 Malleable-Iron Fittings

Fittings shall be ASME B16.3 or KS B 1531, type as required to match connecting piping.

2.12.12.7 Unions

Unions shall be ASME B16.39, Class 150 or KS B 1531 ground joint.

2.12.12.8 Threads

Pipe threads shall conform to ASME B1.20.2M (ASME B1.20.1) or KS B 0222.

2.12.12.9 Grooved Mechanical fittings

Joints and fittings shall be designed for not less than 862 kPa (125 psig) service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D2000 for circulating medium up to 110 degrees C (230 degrees F). Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183.

2.12.13 Copper Tubing and Fittings

2.12.13.1 Copper Tubing

Tubing shall be ASTM B88, ASTM B88M, Type K or L or KS D 5301. Adapters for copper tubing shall be brass or bronze for brazed fittings.

2.12.13.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 andASTM B75/B75M or KS D 5578. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 or KS D 5578 and ASTM B828.

2.12.13.3 Flared Fittings

Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 or KS B 1545 and ASTM B62.

2.12.13.4 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.12.13.5 Threaded Fittings

Cast bronze threaded fittings shall conform to ASME B16.15.

2.12.13.6 Brazing Material

Brazing material shall conform to AWS A5.8/A5.8M or KS D 8319.

2.12.13.7 Brazing Flux

Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Silver brazing materials shall be in accordance with AWS A5.8/A5.8M or KS D 8319.

2.12.13.8 Solder Material

Solder metal shall conform to ASTM B32 95-5 tin-antimony or KS D 6704.

2.12.13.9 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to ASTM B813.

2.12.13.10 Grooved Mechanical Fittings

Joints and fittings shall be designed for not less than 862 kPa (125 psig) service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsible configuration and shall conform to ASTM D2000, for circulating medium up to 110 degrees C (230 degrees F). Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183.

2.12.14 Dielectric Waterways and Flanges

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.12.15 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 862 kPa (125 psi) or 1034.2 kPa (150 psi) service. Connectors shall be installed where indicated. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration shall be suitable for the pressure, vacuum, and temperature medium. The flexible section shall be suitable for service intended and may have threaded, welded, soldered, flanged, or socket ends. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.12.16 Pipe Supports

Pipe supports shall conform to MSS SP-58 and MSS SP-69.

2.12.17 Pipe Expansion

2.12.17.1 Expansion Loops

Expansion loops and offsets shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops and offsets shall be cold-sprung and installed where indicated. Pipe guides and anchors shall be provided as indicated.

2.12.17.2 Expansion Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the transverse indicated. The joints shall be designed for a hot water or steam working pressure not less than 862 kPa (125 psig) and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1 or KS B 1536. End connection shall be flanged. Anchor bases or support bases shall be provided as indicated or required. Sliding surfaces and water wetted surfaces shall be chromium plated or fabricated of corrosion resistant steel. Initial setting shall be made in accordance with the manufacturer's recommendations to compensate for an ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall not be more than 1.5 m (5 feet) from expansion joint, except in lines 100 mm (4 inches) or smaller guides shall be installed not more than 600 mm (2 feet) from the joint. Service outlets shall be provided where indicated.

a. Bellows-type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows-type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 or KS B 1536 with internal lines. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but shall not be less than 1135 kPa (150 psig).

b. Flexible ball joints shall be constructed of alloys as appropriate for the service intended. The joints shall be threaded, grooved, flanged, or welded end as required and shall be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Balls and sockets shall be polished, chromium-plated when materials are not of corrosion-resistant steel. The ball type joint shall be designed and constructed in accordance with ASME B31.1 and EJMA Stds. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets shall be suitable for the service intended.

c. Slip type expansion joints shall be EJMA Stds and ASME B31.1, Class 1 or 2. Type II joints shall be suitable for repacking under full line pressure.

2.12.18 Valves

Valves shall be Class 125 and shall be suitable for the application. Grooved ends in accordance with AWWA C606 may be used for water service only. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves shall match the same type of connection required for the piping on which installed.

2.12.18.1 Gate Valves

Gate valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 bronze rising stem, threaded, solder, or flanged ends or KS B 2301. Gate valves 80 mm (3 inches) and larger shall conform to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

2.12.18.2 Globe Valves

Globe valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends or KS B 2301. Globe valves 80 mm (3 inches) and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.3 Check Valves

Check valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends or KS B 2301. Check valves 80 mm (3 inches) and larger shall conform to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.4 Angle Valves

Angle valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 bronze, threaded, soldered, or flanged ends or KS B 2301. Angle valves 80 mm (3 inches) and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.5 Ball Valves

Ball valves 15 mm (1/2 inch) and larger shall conform to MSS SP-72 or MSS SP-110, ductile iron or bronze, threaded, soldered, or flanged ends.

2.12.18.6 Plug Valves

Plug valves 51 mm (2 inch) and larger shall conform to MSS SP-78. Plug valves smaller than 51 mm (2 inch) shall conform to ASME B16.34.

2.12.18.7 Grooved End Valves

Valves with grooved ends in accordance with AWWA C606 may be used if the valve manufacturer certifies that their performance meets the requirements of the standards indicated for each type of valve.

2.12.18.8 Balancing Valves

Balancing valves shall have meter connections with positive shutoff valves. An integral pointer shall register the degree of valve opening. Valves shall be calibrated so that flow rate can be determined when valve opening in degrees and pressure differential across valve is known. Each balancing valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valves shall be suitable for 120 degrees C (250 degrees F) temperature and working pressure of the pipe in which installed. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter shall be furnished. The meter suitable for the operating pressure specified shall be complete with hoses, vent, and shutoff valves, and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.12.18.9 Automatic Flow Control Valves

In lieu of the specified balancing valves, automatic flow control valves may be provided to maintain constant flow and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 862 kPa (125 psi) or 150 percent of the system operating pressure, whichever is greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be increased. Valves shall be suitable for 120 degrees C (250 degrees F) temperature service. Valve materials shall be same as specified for the heating system check, globe, angle, and gate valves. Valve operator shall be the electric motor type or pneumatic type as applicable. Valve operator shall be capable of positive shutoff against the system pump head. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. A portable meter shall be provided with accessory kit as recommended for the project by the automatic valve manufacturer.

2.12.18.10 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 1135 kPa (150 psig). Valve bodies shall be cast iron, malleable iron, or steel. ASTM A167, Type 404 or Type 316 or KS B 2333, corrosion resisting steel stems, bronze, or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 200 mm (8 inches) shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.12.18.11 Drain valves

Drain valves shall be provided at each drain point of blowdown as recommended by the boiler manufacturer. Piping shall conform to ASME BPVC SEC IV and ASTM A53/A53M.

2.12.18.12 Safety Valves

Safety valves shall have steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can occur. Adjustment of the desired back-pressure shall cover the range between 15 and 70 kPa (2 and 10 psig). The adjustment shall be made externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing. Boiler safety valves of proper size and of the required number, in accordance with ASME BPVC SEC IV, shall be installed so that the discharge will be through piping extended to the blowoff tank or to a location as indicated. Each discharge pipe for steam service shall be provided with a drip pan elbow to prevent accumulation of water on the valve. A slip joint shall be provided between drip pan elbow and riser. Each discharge pipe for hot water service shall be pitched away from the valve seat.

2.12.19 Strainers

Basket and "Y" type strainers shall be the same size as the pipelines in which they are installed. The strainer bodies shall be heavy and durable, fabricated of cast iron, and shall have bottoms drilled and tapped with a gate valve attached for blowdown purposes. Strainers shall be designed for 862 kPa (125 psig) service and 176.6 degrees C (350 degrees F). The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment screen. The screen shall be made of 0.795 mm (22 gauge) thick brass sheet, monel, or corrosion-resistant steel with small perforations numbering not less than 6,150/square m (400/square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.12.20 Pressure Gauges

Gauges shall conform to ASME B40.100 or KS B 5305 and shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 90 mm (3-1/2 inches). A pressure gauge shall be provided for each boiler in a visible location on the boiler. Pressure gauges shall be provided with readings in kPa (psi). Pressure gauges shall have an indicating pressure range that is related to the operating pressure of the fluid in accordance with the following table:

Operating Pressure (kPA)	Pressure Range (kPA)
519-1030	0-1400
105-518	0-690
14-104	0-210 (retard)

Operating Pressure (psi)	Pressure Range (psi)
76-150	0-200
16-75	0-100
2-15	0-30 (retard)

2.12.21 Thermometers

Thermometers shall be provided with wells and separable corrosion-resistant steel sockets. Mercury shall not be used in thermometers. Thermometers for inlet water and outlet water for each hot water boiler and the feed water for each steam boiler shall be provided in a visible location on the boiler. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 225 mm (9 inch) scale. The operating range of the thermometers shall be 0-100 degrees C (32-212 degrees F). The thermometers shall be provided with readings in degrees C (F).

2.12.22 Air Vents

2.12.22.1 Manual Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

2.12.22.2 Automatic Air Vents

Automatic air vents shall be 19 mm (3/4 inch) quick-venting float and vacuum air valves. Each air vent valve shall have a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. The name of the manufacturer shall be clearly stamped on the outside of each valve. The air vent valve shall be suitable for the pressure rating of the piping system.

2.12.23 Steam Traps

2.12.23.1 Thermostatic Traps

Thermostatic traps shall conform to the requirements of ASTM F1139 and shall be installed in the return connection from each radiator and elsewhere as indicated. Drip traps for mains, risers, and similar lines shall be installed with a cooling leg of 1.50 m (5 feet) of uncovered 19 mm (3/4 inch) pipe. The capacity of traps shall be based on a pressure differential of 15 kPa (2 psi). The traps shall be designed for a steam working pressure of 100 kPa (15 psig) but shall operate with a supply pressure of approximately 15 kPa (2 psig). The traps shall be angle or straight-through pattern with union inlet connections as indicated. The trap bodies and covers shall be brass. Valve mechanisms and seats shall be monel, stainless steel or hard bronze and shall be removable for servicing or replacement.

2.12.23.2 Float-and-Thermostatic Traps

Float-and-thermostatic traps shall conform to the requirements of ASTM F1139 and be designed for a steam working pressure of 100 kPa (15 psig) but shall operate with a supply pressure of approximately 34 kPa (5 psig). The trap capacity shall be based on a pressure differential of 15 kPa (2 psig). Each float-and-thermostatic trap shall have a cast iron body and shall be provided with a hard bronze, monel, or corrosion-resisting steel valve seat and mechanism, an open- or closed-type float of brass or equally corrosion-resistant metal, and a corrosion-resisting steel thermostatic air vent, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.12.23.3 Inverted Bucket Traps

Inverted bucket traps shall conform to the requirements of ASTM F1139 and be designed for a steam working pressure of 100 kPa (15 psig) but shall operate with a supply pressure of approximately 35 kPa (5 psig). Each trap shall have a cast iron body and shall have a corrosion-resistant steel valve and seat and a brass or corrosion-resistant steel bucket, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.13 ELECTRICAL EQUIPMENT

Electric motor-driven equipment shall be provided complete with motors, motor starters, and necessary control devices. Electrical equipment, motor control devices, motor efficiencies and wiring shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors which are not an integral part of a packaged boiler and which are integral in size shall be the premium efficiency type in accordance with NEMA MG 1. Motors which are an integral part of the packaged boiler shall be the highest efficiency available by the manufacturer of the packaged boiler. Motor starters shall be provided complete with properly sized thermal overload protections and other appurtenances necessary for the motor control specified. Starters shall be furnished in general purpose enclosures, unless otherwise indicated in contract drawings. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices but not shown shall be provided.

2.13.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 375 W (1/2 hp) and larger shall be three-phase, unless otherwise indicated. Motors shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor.

2.13.2 Motor Controls

Motor controllers shall be provided complete with properly sized thermal overload protection. Manual or automatic control and protective or signal devices required for the operation specified and any wiring required to such devices shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Solid state variable speed controllers shall be utilized for fractional through 7.46 kW (10 hp) ratings. Adjustable frequency drives shall be used for larger motors.

2.14 INSULATION

Shop and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.15 TOOLS

Special tools shall be furnished. Special tools shall include uncommon tools necessary for the operation and maintenance of boilers, burners, pumps, fans, controls, meters, special piping systems, and other equipment. Small hand tools shall be furnished within a suitable cabinet, mounted where directed.

2.15.1 Breeching Cleaner

A cleaner shall be provided to clean the breeching. The cleaner shall have a jointed handle of sufficient length to clean the breeching without dismantling.

2.15.2 Tube Cleaner

If a watertube boiler is being furnished, a water-driven tube cleaner with three rotary cutters and rotary wire brush complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation shall be provided. Tube cleaner and rotary brush shall be provided for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Necessary valves and fittings shall be provided to permit ready connection of the cleaner hose to a high-pressure pump for cold water supply to operate the cleaner.

2.15.3 Tube Brush

If a fire tube boiler is being furnished, a tube brush, with steel bristles and jointed handle of sufficient length to clean full length of fire tubes, shall be provided.

2.15.4 Wrenches

Wrenches shall be provided as required for specialty fittings such as manholes, handholes, and cleanouts. One set of extra gaskets shall be provided for all manholes and handholes, for pump barrels, and other similar items of equipment. Gaskets shall be packaged and properly identified.

2.16 FUEL OIL STORAGE SYSTEM

The fuel oil storage system shall be as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS unless noted otherwise. A helical wound coil constructed of 25 mm (1 inch) seamless steel tubing plate coil suction bell heater constructed of carbon steel not lighter than 1.9 mm (14 gauge) shall be provided in each tank for No. 6 fuel oil and installed around the suction end of the oil line. The heating coil inlet and outlet connections and the fuel-oil suction and return piping connections shall be attached to the same tank manway cover. An additional manhole located above the heater shall be provided for removal of the heater as a unit.

2.17 BOILER WATER TREATMENT

Submit one hard copy & one digital copy (.pdf - text searchable)of the proposed water treatment plan. The plan shall include a layout, control scheme, a list of the existing water conditions including the items listed in this paragraph, a list of all chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals. The water treatment system shall be capable of feeding chemicals and bleeding the system to prevent corrosion and scale within the boiler and piping distribution system. Submit one hard copy & one digital copy (.pdf - text searchable) of operating and maintenance manuals for the step-by-step water treatment procedures, including procedures for testing the water quality. The water shall be treated to maintain the conditions recommended by the boiler manufacturer. Chemicals shall meet required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. The services of a company regularly engaged in the treatment of boilers shall be used to determine the correct chemicals and concentrations required for water treatment. The company shall maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Filming amines and proprietary chemicals shall not be used. The water treatment chemicals shall remain stable throughout the operating temperature range of the system and shall be compatible with pump seals and other elements of the system.

2.17.1 Make Up Water Analysis

The following makeup water conditions reported as prescribed in ASTM D596 are as indicated in the contract drawings and documents:

Date of Sample	
Temperature	degrees C (degrees F)
Silica (SiO2)	ppm (mg/1)
Insoluble	ppm (mg/1)
Iron and Aluminum Oxides	ppm (mg/1)
Calcium (Ca)	ppm (mg/1)
Magnesium (Mg)	ppm (mg/1)
Sodium and Potassium (Na and K)	ppm (mg/1)
Carbonate (HCO3)	ppm (mg/1)
Sulfate (SO4)	ppm (mg/1)
Chloride (C1)	ppm (mg/1)
Nitrate (NO3)	ppm (mg/1)
Turbidity	unit
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	epm (meq/1)
Noncarbonate Hardness	epm (meq/1)
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	micro-mho/cm

2.17.2 Boiler Water Limits

The boiler manufacturer shall be consulted for the determination of the boiler water chemical composition limits. The boiler water limits shall be as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity	20-200 ppm
Total Alkalinity (CACO3)	900-1200 ppm
Phosphate	30-60 ppm
Tanin	Medium
Dissolved Solids	3000-5000 ppm
Suspended Solids	300 ppm Max
Sodium Sulfite	20-40 ppm Max
Silica	Less than 150 ppm
Dissolved Oxygen	Less than 7 ppm
Iron	10 ppm
pH (Condensate)	7 - 8
Sodium Sulfite	20-40 ppm
Hardness	Less than 2 ppm
pH	9.3 - 9.9

2.17.3 Water Softening System

The water softening system shall be as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.17.4 Chemical Feed Pumps

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The capacity of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of the pumps shall be not less than 1.5 times the pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.17.5 Tanks

The tanks shall be constructed of high density polyethylene or stainless steel with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.17.6 Injection Assemblies

An injection assembly shall be provided at each chemical injection point located along the boiler piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the water line.

2.17.7 Water Meter

The water meter shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the makeup water line, as indicated.

2.17.8 Water Treatment Control Panel

The control panel shall be a NEMA 12, single door, wall-mounted box conforming with NEMA 250. The panel shall be constructed of steel or stainless steel with a hinged door and lock. The panel shall contain, as a minimum, the following functions identified with a laminated plastic nameplate:

a. Main power switch and indicating light

b. MAN-OFF-AUTO selector switch

c. Indicating lamp for blow down

d. Indicating lamp for each chemical feed pump

e. Indicating lamp for the water softener

2.17.9 Sequence of Operation

The flow rate of chemical addition shall be based upon metering the makeup water. The boiler shall be provided with automatic blowdown based upon conductivity or boiler load. The required rate of chemical feed and boiler blowdown shall be determined by the water treatment company.

2.17.10 Chemical Shot Feeder

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.17.11 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC, steel, or stainless steel.

2.17.12 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.17.13 Glycol Feed System

Design the Glycol feed system to automatically maintain the desired glycol content of the closed water recirculation system(s). Each system shall consist of the following components:

2.17.13.1 Supply Tank and Stand

Include a 200 liter (50 gallon) cross lined polyethylene tank and steel support stand. The tank shall have a cover and bottom outlet fitting for pump suction. Equip the tank stand with a pump mounting platform and support for the control panel and level switch.

2.17.13.2 Glycol Pump

Rotary gear type of bronze construction with a capacity of 0.114 liter/sec (1.8 gpm) at 275.8 kPa (40 psi). The pump shall have a 0.35 kw (1/3 horsepower), 1/115V/60hz motor and internal pressure relief. Provide the pump with a discharge check valve and shutoff valve.

2.17.13.3 Pressure Switch

The pressure switch shall be adjustable over the range of 20.7 - 103.4 kPa (3 - 15 psi) with a 42.4 kPa (6 psi) differential and have contacts rated for 115V.

2.17.13.4 Level Switch

Equipped with N/O and N/C contacts to activate upon sensing a low level condition.

2.17.13.5 Control Panel

The control panel shall be installed in a NEMA 1 enclosure with terminal strip and shall include a red low level alarm light, low level alarm bell and silence button, full voltage motor starter for the glycol pump, and a Hand-Off-Auto selector switch.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

3.2 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

Boiler and auxiliary equipment shall be installed in accordance with manufacturer's written instructions. Proper provision shall be made for expansion and contraction between boiler foundation and floor. This joint shall be packed with suitable nonasbestos rope and filled with suitable compound that will not become soft at a temperature of 40 degrees C (100 degrees F). Boilers and firing equipment shall be supported from the foundations by structural steel completely independent of all brickwork. Boiler supports shall permit free expansion and contraction of each portion of the boiler without placing undue stress on any part of the boiler or setting. Boiler breeching shall be as indicated with full provision for expansion and contraction between all interconnected components.

3.3 PIPING INSTALLATION

Unless otherwise specified, nonboiler external pipe and fittings shall conform to the requirements of ASME B31.1. Pipe installed shall be cut accurately to suit field conditions, shall be installed without springing or forcing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease and other foreign material and shall be installed to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of flow with a grade of not less than 0.2 percent (1 inch in 40 feet). Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, final connections to equipment shall be made with malleable-iron unions for steel pipe 65 mm (2-1/2 inches) or less in diameter and with flanges for pipe 80 mm (3 inches) or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Reducing fittings shall be used for changes in pipe sizes. In horizontal hot water lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level to prevent air binding.

3.3.1 Hot Water Piping and Fittings

Pipe shall be black steel or copper tubing. Fittings for steel piping shall be black malleable iron or cast iron to suit piping. Fittings adjacent to valves shall suit valve material. Grooved mechanical fittings will not be allowed for water temperatures above 110 degrees C (230 degrees F).

3.3.2 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

3.3.3 Gauge Piping

Piping shall be copper tubing.

3.3.4 Steam Piping and Fittings

Piping shall be black steel. Fittings shall be black, malleable iron, cast iron or steel. Fittings adjacent to valves shall suit valves specified. Grooved mechanical fittings will not be allowed for steam piping.

3.3.5 Condensate Return Pipe and Fittings

Piping shall be black steel. Fittings shall be malleable iron, cast iron, or steel. Grooved mechanical fittings will not be allowed for condensate piping.

3.3.6 Joints

Joints between sections of steel pipe and between steel pipe and fittings shall be threaded, grooved, flanged or welded as indicated or specified. Except as otherwise specified, fittings 25 mm (1 inch) and smaller shall be threaded; fittings 32 mm (1-1/4 inches) and up to but not including 80 mm (3 inches) shall be either threaded, grooved, or welded; and fittings 80 mm (3 inches) and larger shall be either flanged, grooved, or welded. Pipe and fittings 32 mm (1-1/4 inches) and larger installed in inaccessible conduit or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 65 mm (2-1/2 inches) or smaller in diameter and with flanges for pipe 80 mm (3 inches)inches or larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

3.3.6.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

3.3.6.2 Welded Joints

Welded joints shall be in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improved flow characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Socket weld joints shall be assembled so that the space between the end of the pipe and the bottom of the socket is no less than 1.5 mm (1/16 inch) and no more than 3 mm (1/8 inch).

3.3.6.3 Grooved Mechanical Joints

Grooved mechanical joints may be provided for hot water systems in lieu of unions, welded, flanged, or screwed piping connections in low temperature hot water systems where the temperature of the circulating medium does not exceed 110 degrees C (230 degrees F). Grooves shall be prepared according to the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations. Mechanical joints shall use rigid mechanical pipe couplings, except at equipment connections. At equipment connections, flexible couplings may be used. Coupling shall be of the bolted type for use with grooved end pipes, fittings, valves, and strainers. Couplings shall be self-centering and shall engage in a watertight couple.

3.3.6.4 Flared and Brazed Copper Pipe and Tubing

Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Brazed joints shall be made in conformance with AWS B2.2/B2.2M and CDA A4015 with flux. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver or a silver brazing filler metal. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided in all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Flared or brazed copper tubing to pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing.

3.3.6.5 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines 50 mm (2 inches) and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015.

3.3.6.6 Copper Tube Extracted Joint

An extruded mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.7 Flanges and Unions

Flanges shall be faced true, provided with 1.6 mm (1/16 inch) thick gaskets, and made square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, they shall be provided with flat faces and full face gaskets. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Dielectric pipe unions shall be provided between ferrous and nonferrous piping to prevent galvanic corrosion. The dielectric unions shall have metal connections on both ends. The ends shall be threaded, flanged, or brazed to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Gaskets, flanges, and unions shall be installed in accordance with manufacturer's recommendations.

3.3.8 Branch Connections

3.3.8.1 Branch Connections for Hot Water Systems

Branches from the main shall pitch up or down as shown to prevent air entrapment. Connections shall ensure unrestricted circulation, eliminate air pockets, and permit complete drainage of the system. Branches shall pitch with a grade of not less than 8 mm in 1 m (1 inch in 10 feet). When indicated, special flow fittings shall be installed on the mains to bypass portions of the water through each radiator. Special flow fittings shall be standard catalog products and shall be installed as recommended by the manufacturer.

3.3.8.2 Branch Connections for Steam Systems

Branches shall be taken from the supply mains at an angle of 45 degrees above the horizontal, unless otherwise indicated. The branches from return mains shall be taken from the top or sides, unless indicated otherwise. Branches shall pitch up from the mains toward the undripped risers or radiator connections with a grade of not less than 8 mm in 1 m (1 inch in 10 feet). Connections to ensure unrestricted circulation, eliminate air pockets, and permit the complete drainage of the system.

3.3.9 Steam Connections to Equipment

Steam supply and return connections shall be provided as shown. Connections shall be made with malleable-iron unions or with steel flanges, to match equipment. Valves and traps shall be installed in accordance with the manufacturer's recommendations. The size of the supply and return pipes to each piece of equipment shall not be smaller than the outlets on the equipment.

3.3.10 Steam Risers

The location of risers is approximate. The exact locations of the risers shall be approved. Downfeed risers shall terminate in a dirt pocket and shall be dripped through a trap to the return line.

3.3.11 Air Vents for Steam Systems

Automatic balanced pressure thermostatic air vents shall be installed at the ends of the steam lines and where shown on the drawings. The vents shall be rated for 862 kPa (125 psi) steam service. The outlet of the vent shall be routed to a point designated by the Contracting Officer's Representative. The inlet line shall have a gate valve or ball valve.

3.3.12 Flared, Brazed, and Soldered Copper Pipe and Tubing

Copper tubing shall be flared, brazed, or soldered. Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided on branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing. Brazed joints shall be made in conformance with CDA A4015. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver, or a silver brazing filler metal. Soldered joints shall be made with flux and are only acceptable for lines 50 mm (2 inches) or smaller. Soldered joints shall conform to ASME B31.5 and shall be in accordance with CDA A4015.

3.3.13 Copper Tube Extracted Joint

An extracted mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.14 Supports

Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Threaded rods which are used for support shall not be formed or bent. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.14.1 Seismic Requirements for Supports and Structural Bracing

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as shown on the drawings. Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided in this section. Material used for supports shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.3.14.2 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1500 mm (5 feet) apart at valves.

h. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4500 mm (15 feet), not more than 2400 mm (8 feet) from end of risers, and at vent terminations.

i. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

(1) Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the

pipe or insulation and freely rested on a steel slide plate.

(2) Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches) or by an amount adequate for the insulation, whichever is greater.

j. Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

k. Piping in trenches shall be supported as indicated.

l. Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05 12 00 STRUCTURAL STEEL. Pipe hanger loads suspended from steel joist between panel points shall not exceed 22 kg (50 pounds). Loads exceeding 22 kg (50 pounds) shall be suspended from panel points.

3.3.14.3 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support member shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. The clips or clamps shall be rigidly attached to the common base member. A clearance of 3 mm (1/8 inch) shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.3.15 Anchors

Anchors shall be provided where necessary to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.3.16 Valves

Valves shall be installed where indicated, specified, and required for functioning and servicing of the systems. Valves shall be safely accessible. Swing check valves shall be installed upright in horizontal lines and in vertical lines only when flow is in the upward direction. Gate and globe valves shall be installed with stems horizontal or above. Valves to be brazed shall be disassembled prior to brazing and all packing removed. After brazing, the valves shall be allowed to cool before reassembling.

3.3.17 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated where membranes are involved. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof. Sleeves through walls shall be cut flush with wall surface. Sleeves through floors shall be cut flush with floor surface or extend above top surface of floor a sufficient distance to allow proper flashing or finishing. Sleeves through roofs shall extend above the top surface of roof at least 150 mm (6 inches) for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 6 mm (1/4 inch) between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in waterproofing membrane floors, bearing walls, and wet areas shall be galvanized steel pipe or cast-iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls shall be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS. Metal jackets shall be provided over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

a. Metal jackets shall not be thinner than 0.1524 mm (0.006 inch) thick aluminum, if corrugated, and 0.4 mm (0.016 inch) thick aluminum, if smooth.

b. Metal jackets shall be secured with aluminum or stainless steel bands not less than 9 mm (3/8 inch) wide and not more than 200 mm (8 inches) apart. When penetrating roofs and before fitting the metal jacket into place, a13 mm (1/2 inch) wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 1000 mm (36 inches) above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the back-up material to a minimum distance of 50 mm (2 inches) above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm (12 inches) above material to a minimum distance of 50 mm(2 inches) above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm (12 inches) above the floor; when passing through walls above grade, the jacket shall extend at least 100 mm (4 inches) beyond each side of the wall.

3.3.17.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through waterproofing membranes shall be provided with a 1.6 mm (4 pound) lead flashing or a 0.55 mm (16 ounce) copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and shall set over the membrane in a troweled coating of bituminous cement. The flashing shall extend above the roof or floor a minimum of 250 mm (10 inches). The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 250 mm (10 inches) in diameter which pass through waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

3.3.17.2 Optional Modular Mechanical Sealing Assembly

At the option of the Contractor, a modular mechanical type sealing assembly may be installed in the annular space between the sleeve and conduit or pipe in lieu of a waterproofing clamping flange and caulking and sealing specified above. The seals shall include interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion-protected carbon steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

3.3.17.3 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may consist of standard roof coupling for threaded pipe up to 150 mm (6 inches) in diameter, lead flashing sleeve for dry vents with the sleeve turned down into the pipe to form a waterproof joint, or a tack-welded or banded-metal rain shield around the pipe, sealed as indicated.

3.3.17.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.3.18 Balancing Valves

Balancing valves shall be installed as indicated.

3.3.19 Thermometer Wells

A thermometer well shall be provided in each return line for each circuit in multicircuit systems.

3.3.20 Air Vents

Air vents shall be installed where shown or directed. Air vents shall be installed in piping at all system high points. The vent shall remain open until water rises in the tank or pipe to a predetermined level at which time it shall close tight. An overflow pipe from the vent shall be run to a point designated by the Contracting Officer's representative. The inlet to the air vent shall have a gate valve or ball valve.

3.3.21 Escutcheons

Escutcheons shall be provided at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrews.

3.3.22 Drains

A drain connection with a 25 mm (1 inch) gate valve or 19 mm (3/4 inch) hose bib shall be installed at the lowest point in the return main near the boiler. In addition, threaded drain connections with threaded cap or plug shall be installed on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

3.3.23 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

3.3.24 Direct Venting for Combustion Intake Air and Exhaust Air

The intake air and exhaust vents shall be installed in accordance with NFPA 54 and boiler manufacturer's recommendations. The exhaust vent shall be sloped 20.8 mm/m (1/4 inch/ft) toward the boiler's flue gas condensate collection point.

3.4 GAS FUEL SYSTEM

Gas piping, fittings, valves, regulators, tests, cleaning, and adjustments shall be in accordance with the Section 23 11 25 FACILITY GAS PIPING. Submit proposed test schedules for the heating system and fuel system tests, at least 2 weeks prior to the start of related testing. NFPA 54 shall be complied with unless otherwise specified. Burners, pilots, and all accessories shall be listed in UL FLAMMABLE & COMBUSTIBLE. The fuel system shall be provided with a gas tight, manually operated, UL listed stop valve at the gas-supply connections, a gas strainer, a pressure regulator, pressure gauges, a burner-control valve, a safety shutoff valve suitable for size of burner and sequence of operation, and other components required for safe, efficient, and reliable operation as specified. Approved permanent and ready facilities to permit periodic valve leakage tests on the safety shutoff valve or valves shall be provided.

3.5 FUEL OIL SYSTEM

Fuel oil system shall be installed in accordance with NFPA 31, unless otherwise indicated.

3.5.1 Piping and Storage Tank

Fuel oil piping and storage tanks shall be installed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS, unless indicated otherwise.

3.5.2 Fuel-Oil Storage Tank Heating-Coil Piping

Supply and return piping and fittings for the heating coil shall be installed in accordance with paragraph PIPING INSTALLATION. The hot water or steam supply line to the heating coil shall be provided with an automatic temperature-control valve, a strainer and a three-valve bypass. The return line from the coil shall be provided with a check valve or steam trap and a block valve.

3.5.3 Automatic Safety Shutoff Valve

Oil supply line to each oil burner shall be equipped with an automatically operated valve designed to shut off the oil supply in case of fire in the immediate vicinity of the burner. The valve shall be thermoelectrically actuated or thermomechanically actuated type and shall be located immediately downstream of the manual shutoff valve at the day tank inside of the building. If a day tank is not used, the automatic safety valve shall be located immediately downstream of the building shutoff devices where oil supply line enters the building. A thermoelectrical or thermomechanical detection device shall be located over the oil burner to activate the valve. A fire shutoff valve may be combined with other automatic shutoff devices if listed in UL FLAMMABLE & COMBUSTIBLE.

3.5.4 Earthwork

Excavation and backfilling for tanks and piping shall be as specified in Section 31 00 00 EARTHWORK.

3.6 RADIANT FLOOR HEATING SYSTEM

The radiant floor heating system shall be installed in accordance with HI-004, unless otherwise indicated by the tubing manufacturer's installation instructions. During the installation, all tubing shall be plugged on each end to prevent foreign materials from entering the tubing. All tubing shall be checked for abrasions prior to installation. Tubing with excessive abrasions that damage the oxygen barrier coating will not be acceptable. Tubing with any abrasion that is greater than 10 percent of the minimum wall thickness will not be acceptable. All tubing embedded or concealed by the floor shall be installed without joints. The bending radius of the tubing shall not exceed the values recommended by the tubing manufacturer. The tubing shall be installed in such a manner as to evenly distribute the heat across the floor. Tubing shall not be placed near heat sensitive materials such as water closet seals. Isolation valves shall be installed on each side of each tubing manifold. The manifold and fittings shall be accessible for maintenance. After the system is filled with water or glycol, all air shall be vented from the system. After the system is allowed to stabilize at the operating temperatures of the heating fluid, the system shall be vented again.

3.6.1 Concrete Slab construction

In areas where tubing must cross expansion joints, control joints, or other crack control measures, the tubing shall be installed below the joints. The tubing shall be fastened to the reinforcing steel in accordance with the tubing manufacturer's recommendations. The tubing shall be pressurized prior to and during the concrete pour to ensure system integrity.

3.6.2 Wooden Floor Construction

Tubing shall be fastened to the wood subflooring in accordance with the drawings and the tubing manufacturer's recommendations. The method of attaching the tubing to the flooring shall not cause abrasions on the tubing.

3.6.3 Penetrations to Fire Rated Assemblies

Where pipe pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.7 COLOR CODE MARKING AND FIELD PAINTING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS. Ferrous metal not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.8 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified to supervise the installing, adjusting, and testing of the equipment.

3.9 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.10 HEATING SYSTEM TESTS

Submit the Qualifications of the firms in charge of installation and testing as specified. Submit a statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section. Before any covering is installed on pipe or heating equipment, the entire heating system's piping, fittings, and terminal heating units shall be hydrostatically tested and proved tight at a pressure of 1.5 times the design working pressure, but not less than 689 kPa (100 psi). Submit proposed test procedures for the heating system tests and fuel system tests, at least 2 weeks prior to the start of related testing.

a. Before pressurizing system for test, items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure shall be blanked off or replaced with spool pieces.

b. Before balancing and final operating test, test blanks and spool pieces shall be removed; and protected instruments and equipment shall be reconnected. With equipment items protected, the system shall be pressurized to test pressure. Pressure shall be held for a period of time sufficient to inspect all welds, joints, and connections for leaks, but not less than 2 hours. No loss of pressure will be allowed. Leaks shall be repaired and repaired joints shall be retested.

c. Repair joints shall not be allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, the entire zone that is leaking shall be replaced. If any repair is made above the floor for floor radiant heating systems, access shall be provided for the installed joint. Caulking of joints shall not be permitted.

d. System shall be drained and after instruments and equipment are reconnected, the system shall be refilled with service medium and maximum operating pressure applied. The pressure shall be held while inspecting these joints and connections for leaks. The leaks shall be repaired and the repaired joints retested.

Upon completion of hydrostatic tests and before acceptance of the installation, submit test reports for the heating system tests. Upon completion of testing complete with results, balance the heating system in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and operating tests required to demonstrate satisfactory functional and operational efficiency. The operating test shall cover a period of at least 24 hours for each system, and shall include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

a. Certification of balancing.

b. Time, date, and duration of test.

c. Outside and inside dry bulb temperatures.

d. Temperature of hot water supply leaving boiler or steam pressure.

e. Temperature of heating return water from system at or condensate feed to boiler inlet.

f. Quantity of water feed to boiler.

g. Boiler make, type, serial number, design pressure, and rated capacity.

h. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.

i. Circulating, condensate, or vacuum pump make, model, and rated capacity, and ammeter and voltmeter readings for pump motor during operation.

j. Flue-gas temperature at boiler outlet.

k. Percent carbon dioxide in flue-gas.

l. Grade or type and calorific value of fuel.

m. Draft at boiler flue-gas exit.

n. Draft or pressure in furnace.

o. Quantity of water circulated.

p. Quantity of fuel consumed.

q. Stack emission pollutants concentration.

Indicating instruments shall be read at half-hour intervals unless otherwise directed. Furnish all instruments, equipment, and personnel required for the tests and balancing. Obtain necessary natural gas, water and electricity as specified in Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Provide necessary quantities of propane gas or fuel oil when propane gas or fuel oil is require for testing. Operating tests shall demonstrate that fuel burners and combustion and safety controls meet the requirements of ASME CSD-1, ANSI Z21.13/CSA 4.9, NFPA 85.

3.10.1 Water Treatment Testing

The boiler water shall be analyzed prior to the acceptance of the facility a minimum of once a month for a period of 1 year by the water treatment company. Submit a water quality test report identifying the chemical composition of the boiler water. The report shall include a comparison of the condition of the boiler water with the manufacturer's recommended conditions. Any required corrective action shall be documented within the report. The test report shall identify the condition of the boiler at the completion of 1 year of service. The report shall include a comparison of the condition of the boiler with the manufacturer's recommended operating conditions. The analysis shall include the following information recorded in accordance with ASTM D596.

Date of Sample	
Temperature	degrees C (F)
Silica (SiO2)	ppm (mg/1)
Insoluble	ppm (mg/1)
Iron and Aluminum Oxides	ppm (mg/1)
Calcium (Ca)	ppm (mg/1)
Magnesium (Mg)	ppm (mg/1)
Sodium and Potassium (Na and K)	ppm (mg/1)
Carbonate (HCO3)	ppm (mg/1)
Sulfate (SO4)	ppm (mg/1)
Chloride (C1)	ppm (mg/1)
Nitrate (NO3)	ppm (mg/1)
Turbidity	unit
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	epm (meq/1)
Noncarbonate Hardness	epm (meq/1)
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	micro-mho/cm

If the boiler water is not in conformance with the boiler manufacturer's recommendations, the water treatment company shall take corrective action.

3.10.2 Boiler/Piping Test

At the conclusion of the 1 year period, the boiler and condensate piping shall be inspected for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs shall be made by the water treatment company.

3.11 CLEANING

3.11.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, the boilers and piping shall be thoroughly cleaned by filling the system with a solution consisting of either 0.5 kg (1 pound) of caustic soda or 0.5 kg (1 pound) of trisodium phosphate per 190 L (50 gallons) of water. The proper safety precautions shall be observed in the handling and use of these chemicals. The water shall be heated to approximately 65 degrees C (150 degrees F) and the solution circulated in the system for a period of 48 hours. The system shall then be drained and thoroughly flushed out with fresh water. Strainers and valves shall be thoroughly cleaned. Prior to operating tests, air shall be removed from all water systems by operating the air vents.

3.11.2 Heating Units

Inside space heating equipment, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for fans that are operated during construction, and new filters shall be installed after construction dirt has been removed from the building, and the ducts, plenum, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.12 FIELD TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 16 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests.

a. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations and boiler safety devices.

b. Submit system layout diagrams that show the layout of equipment, piping, and ductwork and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system, framed under glass or laminated plastic, at least 2 weeks prior to the start of related testing. After approval, these items shall be posted where directed.

c. One hard copy & one digital copy (.pdf - text searchable) of the operation and maintenance instructions listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

d. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.13 FUEL SYSTEM TESTS

Submit test reports for the fuel system tests, upon completion of testing complete with results.

3.13.1 Fuel Oil System Test

The fuel oil system shall be tested in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.13.2 Gas System Test

The gas fuel system shall be tested in accordance with the test procedures outlined in NFPA 54.

-- End of Section --

SECTION 23 57 10.00 10

FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2011) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2009) Standard for Malleable Iron

	Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2014) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A515/A515M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated,

	Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2003; E 2009; R 2009) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B251	(2010) General Requirements for Wrought Seamless Copper and Copper-Alloy Tube
ASTM B251M	(2010) General Requirements for Wrought Seamless Copper and Copper-Alloy Tube (Metric)
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B395/B395M	(2013) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B650	(1995; R 2013) Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM B687	(1999; R 2011) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B813	(2010) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2002; R 2010) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials

	for Wire and Cable
ASTM D1384	(2005; R 2012) Corrosion Test for Engine Coolants in Glassware
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D596	(2001; R 2011) Reporting Results of Analysis of Water

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2011) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

HYI-005	(2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2014) Motors and Generators

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes

PLUMBING-HEATING-COOLING CONTRACTORS ASSOCIATION (PHCC)

NAPHCC NSPC	(2009) National Standard Plumbing Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2013) Seismic Design for Buildings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heating System

SD-03 Product Data

Spare Parts
Welding
Framed Instructions

SD-06 Test Reports

Testing and Cleaning
Water Treatment Testing

SD-07 Certificates

Bolts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 QUALITY ASSURANCE

Procedures and welders shall be qualified in accordance with the code under which the welding is specified to be accomplished.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation; and dirt, dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than one month prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Place a plate on each major item of equipment having the manufacturer's name, address, type or style, model or serial number, and catalog number secured to the item of equipment.

2.1.3 Equipment Guards and Access

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Sections 05 50 13 MISCELLANEOUS METAL FABRICATIONS and 05 51 33 METAL LADDERS.

2.1.4 Asbestos Prohibition

Asbestos and asbestos-containing products will not be accepted.

2.1.5 Electrical Work

Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electric equipment (including motor efficiencies), and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Electrical characteristics shall be as specified or indicated. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring, conduit, and connection to power required for controls and devices but not shown shall be provided.

2.2 PIPING, TUBING, AND FITTINGS

2.2.1 General

Piping, tubing, and fittings shall be as follows:

a. Steam pipe shall be black steel with malleable iron or steel fittings.

b. Condensate return piping shall be black steel Schedule 80 with cast iron or malleable iron, Class 250 minimum.

c. High temperature water piping shall be black steel, Schedule 40.

d. Vent piping shall be black steel, Schedule 40, with black malleable iron fittings.

2.2.2 Steel Pipe

Pipe shall conform to ASTM A53/A53M or ASTM A106/A106M, Grade A or B, black steel, Schedule 40, unless otherwise specified. Steel pipe to be bent shall be ASTM A53/A53M, Grade A, standard, or Grade B, extra strong weight. Steam pipe shall be ASTM A53/A53M Grade A.

2.2.3 High Temperature Water Piping

Piping shall be Type S for 40 mm (1-1/2 inches) and smaller, Type S or Type E for pipe 50 mm (2 inches) and larger, schedule 40 steel conforming to ASTM A53/A53M, Grade B; or to ASTM A106/A106M, Grade B.

2.2.4 Gauge Piping

Piping shall be copper tubing for steam and low temperature water. Black steel, ASTM A106/A106M, seamless, Grade A pipe shall be used for high temperature.

2.2.5 Copper Tubing

Tubing shall conform to ASTM B88, ASTM B88M, KS D 5301 Type K or L. Tubing for compressed air tubing shall conform to ASTM B251M (ASTM B251).

2.2.6 High Temperature Water Fittings

Fittings shall be steel welding fittings conforming in physical and chemical properties to ASTM A234/A234M. Buttwelding fittings shall conform to ASME B16.9. Socket welded fittings shall conform to ASME B16.1. Screwed fittings, when required, shall be black forged steel, 2000-pound class, conforming to ASME B16.11. Flanges shall be serrated or raised-faced type.

2.2.7 Malleable Iron Pipe Fittings

Fittings shall conform to ASME B16.3, type required to match adjacent piping.

2.2.8 Cast Iron Pipe Fittings

Fittings shall conform to ASME B16.1 or ASME B16.4 type required to match adjacent piping.

2.2.9 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.2.9.1 Welded Fittings

Welded fittings shall conform to ASTM A234/A234M with WPA marking. Butt welded fittings shall conform to ASME B16.9, and socket welded fittings shall conform to ASME B16.11.

2.2.9.2 Grooved Mechanical Fittings

Standard fittings shall be of malleable iron conforming to ASTM A47/A47M, Grade 32510, or ductile iron conforming to ASTM A536, Grade 65-45-12. Fittings may also be constructed of steel, conforming to ASTM A106/A106M, Grade B or ASTM A53/A53M.

2.2.9.3 Grooved Mechanical Pipe Joints

Pipe joints shall conform to AWWA C606. Grooved mechanical joint fittings shall be full flow factory manufactured forged steel fittings. Fittings, couplings, gaskets, and pipe grooving tool or grooved end pipe shall be products of the same manufacturer. Mechanical pipe couplings shall be of the bolted type and shall consist of a housing fabricated in two or more parts, a synthetic rubber gasket, and nuts and bolts to secure unit together. Housings shall be of malleable iron conforming to ASTM A47/A47M, Grade 32510 or ductile iron conforming to ASTM A536, Grade 65-45-12. Coupling nuts and bolts shall be of steel and conform to ASTM A183. Submit written certification that the bolts furnished comply with the requirements of this specification, provided by the bolt manufacturer. The certification shall include illustrations of product-required markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification. Gaskets shall be of molded synthetic rubber, Type EPDM or Buna-N with central cavity, pressure responsive configuration and shall conform to ASTM D2000.

2.2.10 Joints and Fittings for Copper Tubing

Wrought copper and bronze fittings shall conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy fittings shall conform to ASME B16.18 and ASTM B828. Flared fittings shall conform to ASME B16.26 and ASTM B62. Adaptors may be used for connecting tubing to flanges and threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Cast bronze threaded fittings shall conform to ASME B16.15. Grooved mechanical joints and fittings shall be designed for not less than 862 kPa (125 psig) service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 110 degrees C (230 degrees F). Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A183.

2.2.11 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns., etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M.

2.2.12 Pipe Threads

Pipe threads shall conform to ASME B1.20.2M (ASME B1.20.1).

2.2.13 Nipples

Nipples shall conform to ASTM A733 or ASTM B687, standard weight.

2.2.14 Unions

Unions shall conform to ASME B16.39, type to match adjacent piping.

2.2.15 Adapters

Adapters for copper tubing shall be brass or bronze for soldered fittings.

2.2.16 Dielectric Waterways

Dielectric waterways shall conform to the tensile strength and dimensional requirements specified in ASME B16.39. Waterways shall have metal connections on both ends to match adjacent piping. Metal parts of dielectric waterways shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.2.17 Grooved Mechanical Joints

Rigid grooved pipe joints may be provided in lieu of unions, welded, flanges or screwed piping connections at chilled water pumps and allied equipment, and on aboveground pipelines in serviceable locations, if the temperature of the circulating medium does not exceed 110 degrees C (230 degrees F). Flexible grooved joints will not be permitted, except as vibration isolators adjacent to mechanical equipment. Rigid grooved joints shall incorporate an angle bolt pad design which maintains metal-to-metal contact with equal amount of pad offset of housings upon installation to insure positive rigid clamping of the pipe. Designs which can only clamp on the bottom of the groove or which utilize gripping teeth or jaws, or which use misaligned housing bolt holes, or which require a torque wrench or torque specifications, will not be permitted. Rigid grooved pipe couplings shall be used with grooved end pipes, fittings, valves and strainers. Rigid couplings shall be designed for not less than 862 kPa (125 psi) service and appropriate for static head plus the pumping head, and shall provide a water-tight joint. Grooved fittings and couplings, and grooving tools shall be provided from the same manufacturer. Segmentally welded elbows shall not be used. Grooves shall be prepared in accordance with the coupling manufacturer's latest published standards. Grooving shall be performed by qualified grooving operators having demonstrated proper grooving procedures in accordance with the tool manufacturer's recommendations. The Contracting Officer shall be notified 24 hours in advance of test to demonstrate operator's capability, and the test shall be performed at the work site, if practical, or at a site agreed upon. The operator shall demonstrate the ability to properly adjust the grooving tool, groove the pipe, and verify the groove dimensions in accordance with the coupling manufacturer's specifications.

2.2.18 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 1.034 MPa (125 psi) or 1.034 MPa (150 psi) service as appropriate for the static head plus the system head, and 121 degrees C (250 degrees F). Connectors shall be installed where indicated. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration shall be suitable for the pressure, vacuum, temperature, and circulating medium. The flexible section may have threaded, welded, soldered, flanged, grooved, or socket ends. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.3 MATERIALS AND ACCESSORIES

2.3.1 Iron and Steel Sheets

2.3.1.1 Galvanized Iron and Steel

Galvanized iron and steel shall conform to ASTM A653/A653M, with general requirements conforming to ASTM A653/A653M. Gauge numbers specified are Manufacturer's Standard Gauge.

2.3.1.2 Uncoated (Black) Steel

Uncoated (black) steel shall conform to ASTM A516/A516M, composition, condition, and finish best suited to the intended use. Gauge numbers specified refer to Manufacturer's Standard Gauge.

2.3.2 Solder

Solder shall conform to ASTM B32. Solder and flux shall be lead free. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

2.3.3 Solder, Silver

Silver solder shall conform to AWS A5.8/A5.8M.

2.3.4 Thermometers

Mercury shall not be used in thermometers. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 225 mm (9 inch) scale, and thermometers shall have rigid stems with straight, angular, or inclined pattern.

2.3.5 Gauges

Gauges shall conform to ASME B40.100.

2.3.6 Gaskets for Flanges

Composition gaskets shall conform to ASME B16.21. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.6 mm (1/16 inch) thickness, full face or self-centering flat ring type. Gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). NBR binder shall be used for hydrocarbon service. Gaskets shall be suitable for pressure and temperatures of piping system.

2.3.7 Polyethylene Tubing

Low-density virgin polyethylene shall conform to ASTM D1248, Type I, Category 5, Class B or C.

2.3.8 Bellows-Type Joints

Joints shall be flexible, guided expansion joints. Expansion element shall be of stainless steel. Bellows-type expansion joints shall be in accordance with the applicable requirements of EJMA Stds and ASME B31.1 with internal liners.

2.3.9 Expansion Joints

Expansion joints shall provide for either single or double slip of connected pipes, as required or indicated, and for not less than the traverse indicated. Joints shall be designed for hot water working pressure not less than 862 kPa (125 psig) and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. Joints shall be designed for packing injection under full line pressure. End connections shall be flanged or beveled for welding as indicated. Joints shall be provided with anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip shall be seamless steel plated with a minimum of 0 0508 mm (2 mils) of hard chrome conforming to ASTM B650. Joint components shall be fabricated from material equivalent to that of the pipeline. Initial settings shall be made in accordance with manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by joint manufacturer, but in any case shall not be more than 1.5 m (5 feet) from expansion joint except for lines 100 mm (4 inches) or smaller, guides shall be installed not more than 600 mm (2 feet) from the joint. Service outlets shall be provided where indicated.

2.3.10 Flexible Ball Joints

Flexible ball joints shall be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint shall be designed for packing injection under full line pressure to contain leakage. Joint ends shall be threaded (to 50.8 mm (2 inches) only), grooved, flanged or beveled for welding as indicated or required and shall be capable of absorbing a minimum of 15-degree angular flex and 360-degree rotation. Balls and sockets shall be of equivalent material as the adjoining pipeline. Exterior spherical surface of carbon steel balls shall be plated with 0.0508 mm (2 mils) of hard chrome conforming to ASTM B650. Ball type joints shall be designed and constructed in accordance with

ASME B31.1 and ASME BPVC SEC VIII D1, where applicable. Flanges where required shall conform to ASME B16.5. Gaskets and compression seals shall be compatible with the service intended.

2.3.11 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.4 VALVES FOR HIGH AND MEDIUM TEMPERATURE WATER SYSTEMS

2.4.1 Check Valves

Sizes 65 mm (2-1/2 inches) and less, bronze shall conform to MSS SP-80, Class 300 Sizes 65 mm (2-1/2 inches) and less, bronze shall conform to MSS SP-80, Class 300 minimum. Sizes 80 mm (3 inches) through 600 mm (24 inches), steel shall conform to ASME B16.34, Class 300 minimum, flanged ends, swing disc; water, oil gas or steam service to 454 degrees C (850 degrees F).

2.4.2 Globe Valves

Sizes 65 mm (2-1/2 inches) and less, bronze shall conform to MSS SP-80, Type 1, 2 or 3, Class 300 minimum. Sizes 80 mm (3 inches) through 600 mm (24 inches), steel shall conform to ASME B16.34, Class 300 minimum, flanged ends; water, oil, gas, or steam service to 454 degrees C (850 degrees F).

2.4.3 Angle Valves

Sizes 65 mm (2-1/2 inches) and less, bronze shall conform to MSS SP-80, Type 1, 2 or 3, Class 300 minimum. Sizes 80 mm (3 inches) through 600 mm (24 inches), steel shall conform to ASME B16.34, Class 300 minimum, flanged ends; water, oil, gas, or steam service to 454 degrees C (850 degrees F).

2.4.4 Gate Valves

Sizes 65 mm (2-1/2 inches) and less, bronze shall conform to MSS SP-80, Type 1, or 2, Class 300 minimum. Sizes 80 mm (3 inches) through 600 mm (24 inches), steel shall conform to ASME B16.34, Class 300 minimum, flanged ends; water, oil, gas or steam service to 454 degrees C (850 degrees F). Gate shall be split wedge (double disc) type.

2.5 COLD WATER CONNECTIONS

Connections shall be provided which include consecutively in line a strainer, backflow prevention device, and water pressure regulator. The backflow prevention device shall be provided as indicated and in compliance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.5.1 Strainers

Basket or Y-type strainers shall be the same size as the pipelines in which they are installed. Strainer bodies shall be rated for 0.862 or 1.72 MPa (125 or 250 pound) service, with bottoms drilled and plugged. Bodies shall have arrows cast on the sides to indicate the direction of flow. Each strainer shall be equipped with a removable cover and sediment basket. Basket shall not be less than 0.795 mm (22 gauge) and shall have perforations to provide a net free area through the basket of at least four times that of the entering pipe.

2.5.2 Pressure Regulating Valve

Valve shall be a type that will not stick nor allow pressure to build up on the low side. Valve shall be set to maintain a terminal pressure approximately 35 kPa (5 psi) in excess of the static head on the system and shall operate within a 138 kPa (20 psi) variation regardless of initial pressure and without objectionable noise under any condition of operation.

2.6 FLASH TANK

Tank shall be sized and installed as indicated, and shall be of welded construction utilizing black steel sheets not less than 3.175 mm (11 gauge). Tank shall be provided with a handhole and with tapping for the condensate returns, drip lines, vent line, and condensate discharge line to the condensate receiver. Discharge line shall be equipped with a float trap. Tank shall be ASME rated for 862 kPa (125 psig) in accordance with ASME BPVC SEC VIII D1.

2.7 EXPANSION TANK

Pressurization system shall include a replaceable diaphragm-type captive air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank. Sizes shall be as indicated. Expansion tank shall be welded steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa (125 psig) and precharged to the minimum operating pressure. Tank air chamber shall be fitted with an air charging valve. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations.

2.8 AIR SEPARATOR TANK

External air separation tank shall be steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa (125 psi). The minimum capacity of the air separation tank shall be as indicated.

2.9 STEAM TRAPS

2.9.1 Float Traps

Capacity, working pressure, and differential pressure of the traps shall be as indicated.

2.9.2 Float-and-Thermostatic Traps

Traps shall be designed for a steam working pressure of approximately 103 kPa (15 psig), but shall operate with a supply pressure of approximately 35 kPa (5 psig). The capacity of the traps shall be as indicated. Trap capacity shall be based on a pressure differential of 2 kPa (1/4 psi). Each float-and-thermostatic trap shall be provided with a hard bronze, monel, or stainless steel valve seat and mechanism and brass float, all of which can be removed easily for inspection or replacement without disturbing the piping connections. Inlet to each trap shall have a cast iron strainer, either an integral part of the trap or a separate item of equipment.

2.9.3 Bucket Traps

Traps shall be inverted or vertical bucket type with automatic air discharge. Traps shall be designed for a working pressure of 1034 kPa (150 psig), but shall operate under a steam supply pressure of approximately 276 to 690 kPa (40 to 100 psig) as required. Each trap shall have a heavy body and cap of fine-grained, gray cast iron. The bucket shall be made of brass; the mechanism of hard bronze; the valve and seat of stainless or monel; or each of equivalent material. Traps shall be tested hydrostatically under a pressure of 1.38 MPa (200 psig). Traps shall have capacities as indicated when operating under the specified working conditions. A strainer shall be installed in the suction connection of each trap. Impact operated traps, impulse-operated traps, or thermodynamic traps with continuous discharge may be installed in lieu of bucket traps, subject to approval. Thermostatic traps designed for a steam working pressure suitable for the application may be furnished in lieu of the traps specified above. Thermostatic traps shall be equipped with valves and seats of stainless steel or monel metal, and shall have capacities based on a pressure differential not in excess of the following:

Steam Working Pressure, kPa	Differential, kPa
172 - 345	138
621 - 689	552

Steam Working Pressure, psi	Differential, psi
25-50	20
90-100	80

2.10 HEAT EXCHANGERS

Heat exchangers shall be multiple pass shell and U-tube type or plate and frame type as indicated, to provide low temperature hot water for the heating system when supplied with steam, high temperature hot water, or medium temperature hot water at the temperatures and pressures indicated. Temperature and pressure for plate and frame exchangers shall not exceed 138 degrees C (280 degrees F) and 1.93 MPa (280 psig) for medium temperature hot water, or 138 degrees C (280 degrees F) and 241 kPa (35 psig) for steam. Temperature and pressure for shell and U-tube exchangers shall not exceed 170 degrees C (338 degrees F) and 689 kPa (100 psig) for steam or 221 degrees C (430 degrees F) and 2.76 MPa (400 psig) for high temperature hot water. Exchangers shall be constructed in accordance with ASME BPVC SEC VIII D1 and certified with ASME stamp secured to unit. U-tube bundles shall be completely removable for cleaning and tube replacement and shall be free to expand with shell. Shells shall be of seamless steel pipe or welded steel construction and tubes shall be seamless tubing as specified below unless otherwise indicated. Tube connections to plates shall be leakproof. Saddles or cradles shall be provided to mount shell and U-tube exchangers. Frames of plate and frame type exchangers shall be fabricated of carbon steel and finished with baked epoxy enamel. Design fouling factor shall be 0.0002.

2.10.1 Steam Heat Exchangers, Shell and U-Tube Type

Exchangers shall operate with steam in shell and low temperature water in tubes. Shell and tube sides shall be designed for 1.03 MPa (150 psig) working pressure and factory tested at 2.02 MPa (300 psig). Steam, water, condensate, and vacuum and pressure relief valve connections shall be located in accordance with the manufacturer's standard practice. Connections larger than 80 mm (3 inches) shall be ASME 1.03 MPa (150 pound) flanged. Water pressure loss through clean tubes shall not exceed 41 kPa (6 psi) and water velocity shall not exceed 1.8 m/second (6 fps) unless otherwise indicated. Minimum water velocity in tubes shall be not less than 300 mm/second (1 fps) and assure turbulent flow. Tubes shall be seamless copper or copper alloy, constructed in accordance with ASTM B75/B75M or ASTM B395/B395M, suitable for the temperatures and pressures specified. Tubes shall be not less than 19 mm (3/4 inch) unless otherwise indicated. Maximum steam inlet nozzle velocity shall not exceed 30.5 m/second (6000 fpm).

2.10.2 High Temperature Water Heat Exchangers, Shell and U-tube Type

Exchangers shall operate with low temperature water in shell and high temperature water in tubes. Shell side shall be designed for 1.03 MPa (150 psig) working pressure and factory tested at 2.07 MPa (300 psig). Tubes shall be designed for 2.76 MPa (400 psig) working pressure and an operating temperature of 232 degrees C (450 degrees F). High and low temperature water and pressure relief connections shall be located in accordance with the manufacturer's standard practice. Water connections larger than 80 mm (3 inches) shall be ASME 4.14 MPa (600 pound) flanged for high temperature water, and ASME 4.03 MPa (150 pound) flanged for low temperature water. Water pressure loss through clean tubes shall not exceed 41 kPa (6 psig) unless otherwise indicated. Minimum water velocity in tubes shall be 300 mm/second (1 fps) and assure turbulent flow. Tubes shall be cupronickel or inhibited admiralty, constructed in accordance with ASTM B395/B395M, suitable for the temperatures and pressures specified. Tubes shall be not less than 19 mm (3/4 inch) unless otherwise indicated.

2.10.3 Steam Heat Exchangers, Plate and Frame Type

Plates, frames and gaskets shall be designed for a working pressure of 2.07 MPa (300 psig) and factory tested at 3.10 MPa (450 psig). Steam, low temperature water, condensate, and vacuum and pressure relief valve connections shall be located in accordance with the manufacturer's standard practice. Connections larger than 80 mm (3 inches) shall be ASME 4.03 MPa (150 pound) flanged. Water pressure drop through clean plates and headers shall not exceed 34.5 kPa (5 psig) at the flow rates and temperatures indicated. Plates shall be designed to assure turbulent flow at a minimum flow rate through any 2 plate segment as indicated on contract drawings. Plates shall be corrugated Type 304 stainless steel. Plate thickness shall be not less than 0.8 mm (0.03 inch).

2.10.4 Medium Temperature Water Heat Exchangers, Plate and Frame Type

Plates, frames and gaskets shall be designed for a working pressure of 2.07 MPa (300 psig) and factory tested at 31.0 MPa (450 psig). Medium temperature water, low temperature water, and pressure relief valve connections shall be located in accordance with the manufacturer's standard practice. Connections larger than 80 mm (3 inches) shall be ASME

2.07 MPa (300 pound) flanged. Water pressure drop through clean plates and headers shall not exceed 34.5 kPa (5 psi) at the flow rates and temperatures indicated. Plates shall be designed to assure turbulent flow at a minimum flow rate through any 2 plate segment as indicated on contract drawings. Plates shall be corrugated Type 304 stainless steel. Plate thickness shall be not less than 0.8 mm (0.03 inch).

2.11 SYSTEM EQUIPMENT AND ACCESSORIES

2.11.1 Circulating Pumps

Pumps for hot water shall be of the single-stage centrifugal type, electrically driven. Pumps shall be supported on a concrete foundation or by the piping on which installed, as indicated on contract drawings. Pumps shall be either integrally mounted with the motor or direct-connected by means of a flexible-shaft coupling on a cast iron, or steel sub-base. Pump housing shall be of close grained cast iron. Shaft shall be carbon or alloy steel, turned and ground. Shaft seal shall be mechanical-seal or stuffing-box type. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Bearings shall be ball-, roller-, or oil-lubricated, bronze-sleeve type, and shall be sealed or isolated to prevent loss of oil or entrance of dirt or water. Motor shall be of a type approved by the manufacturer of the pump.

2.11.2 Condensate Pumping Unit

Pump shall have a minimum capacity, as indicated, when discharging against the specified pressure. The minimum capacity of the tank shall be as indicated on the drawings. Condensate pumping unit shall be of the single or duplex, horizontal-shaft or vertical-shaft type, as indicated. Unit shall consist of one pump or two pumps, one or two electric motors and a single receiver. Pumps shall be centrifugal or turbine type, bronze-fitted throughout with impellers of bronze or other corrosion-resistant metal. Pumps shall be free from air-binding when handling condensate with temperatures up to 93 degrees C (200 degrees F). Pumps shall be connected directly to drip-proof enclosed motors. Receiver shall be cast iron and shall be provided with condensate return, vent, overflow, and pump suction connections, and water level indicator and automatic air vent. Inlet strainer shall be provided in the inlet line to the tank. Vent pipe shall be galvanized steel, and fittings shall be galvanized malleable iron. Vent pipe shall be installed as indicated or directed. Vent piping shall be flashed as specified. Pump, motor, and receiving tank may be mounted on a single base with the receiver piped to the pumps suctions. A gate valve and check valve shall be provided in the discharge connection from each pump.

2.11.2.1 Controls

Enclosed float switches complete with float mechanisms shall be installed in the head of the receiver. The condensate pump shall be controlled automatically by means of the respective float switch that will automatically start the motor when the water in the receiving tank reaches the high level and stop the motor when the water reaches the low level. Motors shall be provided with magnetic across-the-line starters equipped with general purpose enclosure and Automatic-Manual-Off selector switch in the cover.

2.11.2.2 Factory Testing

Submit a certificate of compliance from the pump manufacturer covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

2.11.3 Pressure Gauges and Thermometers

Gauges shall be provided for each heat exchanger and piping as indicated. A thermometer and pressure gauge shall be provided on the high temperature water supply and return mains. Thermometers shall be separable socket type.

2.11.4 Vacuum Relief Valve

Vacuum relief valve shall be installed on the shell of each shell and U-tube steam heat exchanger and on the factory supplied steam inlet nozzle of each plate and frame heat exchanger. On shutoff of steam supply and condensing of steam, the vacuum relief valve shall automatically admit air to the heat exchanger.

2.11.5 Pressure Relief Valves

One or more pressure relief valves shall be provided for each heat exchanger in accordance with ASME BPVC SEC VIII D1. The aggregate relieving capacity of the relief valves shall be not less than that required by the above code. Discharge from the valves shall be installed as indicated. Pressure relief valves for steam heat exchangers shall be located on the low temperature water supply coming from near the heat exchanger as indicated. Relief valves for high temperature water heat exchanger shall be installed on the heat exchanger shell.

2.11.6 Drains

A drain connection with 19 mm (3/4 inch) hose bib shall be installed at the lowest point in the low temperature water return main near the heat exchanger. In addition, threaded drain connections with threaded cap or plug shall be installed wherever required for thorough draining of the low temperature water system.

2.11.7 Strainers

Basket or Y-type strainer-body connections shall be the same size as the pipe lines in which the connections are installed. The bodies shall have arrows clearly cast on the sides to indicate the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment basket. The body or bottom opening shall be equipped with nipple and gate valve for blowdown. The basket for steam systems shall be of not less than 0.635 mm (0.025 inch) thick stainless steel, or monel with small perforations of sufficient number to provide a net free area through the basket of at least 2.5 times that of the entering pipe. The flow shall be into the basket and out through the perforations. For high temperature water systems, only cast steel bodies shall be used. The strainer bodies for steam systems shall be of cast steel or gray cast iron with bottoms drilled and plugged.

2.12 INSULATION

Shop and field applied insulation shall be as specified in Section 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.13 FACTORY PAINTED EXPOSED SPACE HEATING EQUIPMENT

Radiator and convector enclosures shall be coated with the manufacturer's standard rust inhibiting primer for painting in the field as specified in Section 09 90 00 PAINTS AND COATINGS. All other exposed heating equipment shall be painted at the factory with the manufacturer's standard primer and enamel finish.

2.14 RADIATORS AND CONVECTORS

The radiator and convector shall be the type and size indicated. The supply and return connections shall be the same size. Cast iron radiators and nonferrous convectors shall be tested hydrostatically at the factory and proved tight under a pressure of not less than 1379 kPa (200 psig). A certified report of these tests shall be furnished in accordance with paragraph SUBMITTALS.

2.14.1 Cast Iron Radiators

Cast iron radiators shall be gray cast iron, free from sand holes and other defects. The sections shall be connected with malleable iron nipples not less than 2.286 mm (0.09 inch) thick at any point. Cast iron radiators shall be the legless type mounted on the walls by means of hangers as specified. Adjustable radiator hangers shall be secured to the wall and shall hold the radiators near both ends, at both top and bottom, is such manner that the radiators cannot be removed without the use of tools. Not less than two bolts shall be used to secure each hanger to the wall. Necessary angles, bolts, bearing plates, toggles, radiator grips, and other parts required for complete installation of the radiators shall be provided.

2.14.2 Extended-Surface, Steel, or Nonferrous Tube-Type Radiators

Radiators shall consist of metal fins permanently bonded to steel or nonferrous pipe cores, with threaded or sweat fittings at each end for connecting to external piping. Radiators shall have capacities not less than those indicated, determined in accordance with HYI-005. Radiators shall be equipped with expanded-metal cover grilles fabricated from black steel sheets not less than 1.519 mm (16 gauge), secured either directly to the radiators or to independent brackets. solid-front, slotted horizontal-top cover grilles fabricated from black steel sheets not less than 1.214 mm (18 gauge), secured either directly to the radiators or to independent brackets. solid-front, slotted sloping-top cover grilles fabricated from black steel sheets not less than 1.519 mm (16 gauge), independently secured to masonry with brackets.

2.14.3 Convectors

Convectors shall be constructed of cast iron or of nonferrous alloys, and shall be installed where indicated. Capacity of convectors shall be as indicated. Overall space requirements for convectors shall not be greater than the space provided. Convectors shall be complete with heating elements and enclosing cabinets having bottom recirculating opening, manual control damper and top supply grille. Convector cabinets shall be constructed of black sheet steel not less than 0.912 mm (20 gauge).

2.14.4 Radiators and Convectors Control

The space temperature shall be maintained automatically by regulating water flow to the radiators and convectors by the self contained, automatic thermostatic radiator control valves. Controls shall be provided as specified in Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

2.15 UNIT HEATERS

Heaters shall be as specified below, and shall have a heating capacity not in excess of 125 percent of the capacity indicated. Noise level of each unit heater for areas noted shall not exceed the criteria indicated.

2.15.1 Propeller Fan Heaters

Heaters shall be designed for suspension and arranged for horizontal or vertical discharge of air as indicated. Casings shall be not less than 0.912 mm (20 gauge) black steel and finished with lacquer or enamel. Suitable stationary or rotating air deflectors shall be provided to assure proper air and heat penetration capacity at floor level based on established design temperature. Suspension from heating pipes will not be permitted. Fans for vertical discharge type heaters shall operate at speeds not in excess of 1,200 rpm, except that units with 84.4 MJ (80,000 Btu) output capacity or less may operate at speeds up to 1,800 rpm. Horizontal discharge type unit heaters shall have discharge or face velocities not in excess of the following:

Unit Capacity, Liters per Second	Face Velocity, Meters per Second
Up to 472	4.06
473	4.57
1417	5.08

Unit Capacity, cfm	Face Velocity, fpm
Up to 1,000	800
1,001 to 3,000	900
3,001 and over	1,000

2.15.2 Centrifugal Fan Heaters

Heaters shall be arranged for floor or ceiling mounting as indicated. Heating elements and fans shall be housed in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Cabinets shall be constructed of not lighter than 1.27 mm (18 gauge) black steel. Each unit heater shall be provided with a means of diffusing and distributing the air. Fans shall be mounted on a common shaft, with one fan to each air outlet. Fan shaft shall be equipped with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater shall be the same size.

2.15.3 Heating Elements

Heating coils and radiating fins shall be of suitable nonferrous alloy with threaded or brazed fittings at each end for connecting to external piping. The heating elements shall be free to expand or contract without developing leaks and shall be properly pitched for drainage. The elements shall be tested under a hydrostatic pressure of 1.38 MPa (200 psig) and a certified report of the test shall be submitted to the Contracting Officer. Heating coils shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM for types indicated. Coils shall be suitable for use with water up to 121 degrees C (250 degrees F).

2.15.4 Motors

Motors shall be provided with NEMA 250 general purpose enclosure. Motors and motor controls shall otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.15.5 Motor Switches

Motors shall be provided with manual selection switches with "Off," and "Automatic" positions and shall be equipped with thermal overload protection.

2.15.6 Controls

Controls shall be provided as specified in 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

2.16 HEATING AND VENTILATING UNITS

Heating and ventilating units shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.17 WATER TREATMENT SYSTEM

The water treatment system shall be capable of manually or automatically feeding chemicals into the heating system to prevent corrosion and scale within the heat exchanger and piping system. Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Also show on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout and anchorage of equipment and appurtenances and equipment relationship to other parts of the work including clearances for maintenance and operation. All water treatment equipment and chemicals shall be furnished and installed by a water treatment company regularly engaged in the installation of water treatment equipment and the provision of water treatment chemicals based upon water condition analyses. The water treatment company shall provide a water sample analysis taken from the building site, each month for one year.

2.17.1 Chemical Shot Feeder

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping. All materials of construction shall be compatible with the chemicals being used.

2.17.2 Make Up Water Analysis

The following make up water conditions reported as prescribed in ASTM D596 are as indicated in the contract drawings and documents:

Date of Sample	
Temperature	degrees C (F)
Silica (SiO2)	ppm (mg/1)
Insoluble	ppm (mg/1)
Iron and Aluminum Oxides	ppm (mg/1)
Calcium (Ca)	ppm (mg/1)
Magnesium (Mg)	ppm (mg/1)
Sodium and Potassium (Na and K)	ppm (mg/1)
Carbonate (HCO3)	ppm (mg/1)
Sulfate (SO4)	ppm (mg/1)
Chloride (C1)	ppm (mg/1)
Nitrate (NO3)	ppm (mg/1)
Turbidity	unit
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	ppm (meq/1)
Noncarbonate Hardness	epm (meq/1)
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	microsiemens/cm

2.17.3 Chemicals

The chemical company shall provide pretreatment chemicals that will remove and permit flushing of mill scale, oil, grease, and other foreign matter from the water heating system. The chemical company shall also provide all treatment chemicals required for the initial fill of the system and for a period of one year of operation. The chemical company shall determine the correct chemicals and concentrations required for the water treatment. The chemicals shall not be proprietary and shall meet required federal, state, and local environmental regulations for the treatment of heating water systems and discharge to the sanitary sewer. The chemicals shall remain stable throughout the operating temperature range of the system, and shall be compatible with pump seals and other elements of the system.

2.17.4 Glycol Solutions

A 25 percent concentration by volume of industrial grade propylene glycol shall be provided. The glycol shall be tested in accordance with ASTM D1384 with less than 0.013 mm (0.5 mils) penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors shall not be used. The solution shall be compatible with pump seals, other elements of the system, and all water treatment chemicals used within the system.

2.17.5 Test Kits

All required test kits and reagents for determining the proper water conditions shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install all work as indicated and in accordance with the manufacturer's diagrams and recommendations.

3.3 COLOR CODE MARKING AND FIELD PAINTING

Color code marking, field painting of exposed pipe, and field painting of factory primed equipment shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 WELDING

Submit one hard copy & one digital copy (.pdf - text searchable) of the qualified procedures and list of names and identification symbols of qualified welders and welding operators, prior to welding operations. Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL. Welding and nondestructive testing procedures for piping shall be as specified in Section 40 05 13.96 WELDING, PRESSURE PIPING.

3.5 PIPING

Unless otherwise specified, pipe and fittings installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the job site and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cuttings or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall be so installed as to permit free expansion and contraction without causing damage to building structure, pipe, joints, or hangers. Changes in direction shall be made with factory made fittings, except that bending of pipe up to 100 mm (4 inches) will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center line radius of bends shall not be less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be installed through the roof as indicated and shall be flashed as specified. Horizontal mains shall pitch up or down in the direction of flow as indicated. The grade shall be not less than 25 mm in 12 m (1 inch in 40 feet). Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unions and other components for copper pipe or tubing shall be brass or bronze. Connections between ferrous and copper piping shall be electrically isolated using dielectric unions.

3.5.1 Joints

Except as otherwise specified, joints used on steel pipe shall be threaded for fittings 25 mm (1 inch) and smaller; threaded or welded for 32 mm (1-1/4 inches) up through 65 mm (2-1/2 inches); and flanged or welded for 80 mm (3 inches) and larger. Joints between sections of copper tubing or copper pipe shall be flared or sweated. Pipe and fittings 32 mm (1-1/4 inches) and larger installed in inaccessible conduits or trenches beneath concrete floor slabs shall be welded. Unless otherwise specified, connections to equipment shall be made with black malleable iron unions for pipe 65 mm (2-1/2 inches) or smaller in diameter, and with flanges for pipe 80 mm (3 inches) or larger in diameter.

3.5.2 Low Temperature Systems

Piping may have threaded, welded, flanged or flared, sweated, or grooved mechanical joints as applicable and as specified. Reducing fittings shall be used for changes in pipe sizes. In horizontal lines, reducing fittings shall be the eccentric type to maintain the top of the adjoining pipes at the same level.

3.5.3 Steam Systems

Piping may have threaded, welded, or flanged joints as applicable and as specified. Reducing fittings shall be used for changes in pipe sizes. In horizontal steam lines, reducing fittings shall be the eccentric type to maintain the bottom of the lines at the same level. Grooved mechanical joints shall not be used.

3.5.4 High And Medium Temperature Systems

Temperature systems shall have welded joints to the maximum extent practicable, except screwed joints and fittings may be used at connections to equipment and on piping 65 mm (2-1/2 inches) and smaller. Equipment connections 80 mm (3 inches) and larger shall be flanged. Piping connections 80 mm (3 inches) and larger may be welded or flanged. In horizontal lines, reducing fittings shall be the eccentric type to maintain the tops of adjoining pipes at the same level. Grooved mechanical joints shall not be used.

3.5.5 Threaded Joints

Threaded joints shall be made with tapered threads properly cut, and shall be made tight with PTFE tape complying with ASTM D3308, or equivalent thread joint compound applied to the male threads only, and in no case to the fittings.

3.5.6 Welded Joints

Joints shall be fusion-welded unless otherwise required. Changes in direction of piping shall be made with welding fittings only. Branch connection may be made with either welding tees or branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains.

3.5.7 Flanged Joints or Unions

Flanged joints or unions shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and similar items. Flanged joints shall be faced true, provided with gaskets, and made square and tight. Full-faced gaskets shall be used with cast iron flanges.

3.5.8 Flared and Sweated Pipe and Tubing

Pipe and tubing shall be cut square and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned with an abrasive before sweating. Care shall be taken to prevent annealing of fittings and hard drawn tubing when making connection. Installation shall be made in accordance with the manufacturer's recommendations. Changes in direction of piping shall be made with flared or soldered fittings only. Solder and flux shall be lead free. Joints for soldered fittings shall be made with silver solder or 95:5 tin-antimony solder. Cored solder shall not be used. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided on all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing.

3.5.9 Mechanical Tee Joint

An extracted mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Joints shall be brazed in accordance with NAPHCC NSPC. Soldered joints will not be permitted.

3.5.10 Grooved Joints for Copper Tube

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.6 CONNECTIONS TO EQUIPMENT

Supply and return connections shall be provided by the Contractor unless otherwise indicated. Valves and traps shall be installed in accordance with the manufacturer's recommendations. Unless otherwise indicated, the size of the supply and return pipes to each piece of equipment shall be not smaller than the connections on the equipment. No bushed connections shall be permitted. Change in sizes shall be made with reducers or increasers only.

3.6.1 Low Temperature Water and Steam and Return Connections

Connections, unless otherwise indicated, shall be made with malleable iron unions for piping 65 mm (2-1/2 inches) or less in diameter and with flanges for pipe 80 mm (3 inches) or more in diameter.

3.6.2 High And Medium Temperature Water Connections

Connections shall be made with 13.8 MPa (2000 pound) black malleable iron unions for pipe 19 mm (3/4 inch) or less in diameter and with flanges for pipe 25 mm (1 inch) and larger in diameter.

3.7 BRANCH CONNECTIONS

Branches shall pitch up or down as indicated, unless otherwise specified. Connection shall be made to insure unrestricted circulation, eliminate air pockets, and permit drainage of the system.

3.7.1 Low Temperature Water Branches

Branches taken from mains shall pitch with a grade of not less than 25 mm in 3 m (1 inch in 10 feet). Special flow fittings shall be installed on the mains to bypass portions of water through each radiator. Special flow fittings shall be installed as recommended by the manufacturer.

3.7.2 Steam Supply and Condensate Branches

Branches taken from mains shall pitch with a grade of not less than 25 mm in 3 m (1 inch in 10 feet), unless otherwise indicated.

3.7.3 High And Medium Temperature Water Branches

Branches shall take off at 45 degrees in the direction of the fluid flow from the supply and return lines and should be branched from the top or upper half of the main line unless otherwise indicated. Abrupt reduction in pipe sizes shall be avoided.

3.8 RISERS

The location of risers is approximate. Exact locations of the risers shall be as approved. Steam supply downfeed risers shall terminate in a dirt pocket and shall be dripped through a trap to the return line.

3.9 SUPPORTS

3.9.1 General

Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. All piping subjected to vertical movement when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers. Where threaded rods are used for support, they shall not be formed or bent.

3.9.1.1 Seismic Requirements for Pipe Supports, Standard Bracing

All piping and attached valves shall be supported and braced to resist seismic loads as specified under UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as shown on the drawings. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for supports shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.9.1.2 Structural Attachments

Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05 12 00 STRUCTURAL STEEL. Pipe hanger loads suspended from steel joist panel points shall not exceed 222 N (50 pounds). Loads exceeding 222 N (50 pounds) shall be suspended from panel points.

3.9.1.3 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run.

3.9.2 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts and supports shall conform to MSS SP-58 and MSS SP-69, except as specified as follows:

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe and if the clamp bottom does not extend through the insulation and the top clamp attachment does not contact the insulation during pipe movement.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle shall be used on all pipe 100 mm (4 inches) and larger.

h. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves.

i. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m (15 feet), except that pipe shall be supported not more than 2.4 m (8 feet) from end of risers, and at vent terminations.

j. Type 35 guides using steel, reinforced PTFE or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions and bearing loads encountered. Where steel slides do not require provision for restraint or lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle may be welded to the pipe and freely rest on a steel plate. On piping under 100 mm(4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate. Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches) or by an amount adequate for the insulation, whichever is greater.

k. Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

3.9.3 Piping in Trenches

Piping shall be supported as indicated.

3.10 PIPE SLEEVES

3.10.1 Pipe Passing Through Concrete or Masonry

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Unless otherwise indicated, sleeves shall provide a minimum of 6 mm (1/4 inch) annular space between bare pipe or insulation surface and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas shall be steel pipe or cast iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be steel pipe, cast iron pipe, or galvanized sheet metal with lock-type longitudinal seam and of the metal thickness indicated. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in non-fire-rated walls and floors shall be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS. Penetrations in fire walls and floors shall be sealed in accordance with Section 07 84 00 FIRESTOPPING.

3.10.2 Pipes Passing Through Waterproofing Membranes

Pipes passing through waterproofing membranes shall be installed through a 19.5 kg/square meter (4 pound) lead-flashing sleeve, a 4.9 kg/square meter (16 ounce) copper sleeve, or a 0.813 mm (0.032 inch) thick aluminum sleeve, each having an integral skirt or flange. Flashing sleeve shall be suitably formed, and the skirt or flange shall extend 200 mm (8 inches) or more from the pipe and shall be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 inches) above the highest flood level of the roof or a minimum of 250 mm (10 inches) above the roof, whichever is greater, or 250 mm (10 inches) above the floor. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. At the Contractor's option, pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

3.10.3 Mechanical Seal Assembly

In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.10.4 Counterflashing Alternate

As an alternate to caulking and sealing the annular space between the pipe and flashing sleeve or metal-jacket-covered insulation and flashing sleeve, counterflashing may be by standard roof coupling for threaded pipe up to 150 mm (6 inches) in diameter; lead-flashing sleeve for dry vents and turning the sleeve down into the pipe to form a waterproof joint; or tack-welded or banded-metal rain shield round the pipe and sealing as indicated.

3.10.5 Waterproofing Clamping Flange

Pipe passing through wall waterproofing membrane shall be sleeved as specified. In addition, a waterproofing clamping flange shall be installed as indicated.

3.10.6 Fire Seal

Where pipes pass through fire walls, fire partitions, fire rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.10.7 Escutcheons

Escutcheons shall be provided at all finished surfaces where exposed piping, bare or covered, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe sleeves or to extensions of sleeves without any part of sleeves being visible. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheons shall be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrew.

3.11 ANCHORS

Anchors shall be provided where necessary or indicated to localize expansion or prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed using turnbuckles where required. Supports, anchors, or stays shall not be attached in places where construction will be damaged by installation operations or by the weight or expansion of the pipeline.

3.12 PIPE EXPANSION

The expansion of supply and return pipes shall be provided for by changes in the direction of the run of pipe, by expansion loops, or by expansion joints as indicated. Low temperature water and steam expansion joints may be one of the types specified. High or Medium temperature water system expansion joints may be one of the joints specified, except slip-tube type.

3.12.1 Expansion Loops

Expansion loops shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops shall be cold-sprung and installed where indicated. Pipe guides shall be provided as indicated.

3.12.2 Slip-Tube Joints

Slip-tube type expansion joints shall be used for steam and low temperature water systems only and shall be installed where indicated. The joints shall provide for either single or double slip of the connected pipes as indicated and for the traverse indicated. The joints shall be designed for a working temperature and pressure suitable for the application and in no case less than 862 kPa (125 psig). The joints shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connections shall be flanged. Anchor bases or support bases shall be provided as indicated or required. Initial setting shall be made in accordance with the manufacturer's recommendations to allow for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall be not more than 1.5 m (5 feet) from expansion joint, except in lines 100 mm (4 inches) or smaller where guides shall be installed not more that 600 mm (2 feet) from the joint.

3.12.3 Bellows-Type Joint

Bellows-type joint design and installation shall comply with EJMA Stds standards. The joints shall be designed for the working temperature and pressure suitable for the application and shall be not less than 1.03 MPa (150 psig) in any case.

3.12.4 Flexible Ball Joints

Flexible ball joints may be threaded (to 50 mm (2 inches) only), flanged, or welded end as required. The ball-type joint shall be designed and constructed in accordance with the generally accepted engineering principle stated in ASME B31.1, and ASME BPVC SEC VIII D1, where applicable. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets furnished shall be suitable for the service intended.

3.13 VALVES AND EQUIPMENT ACCESSORIES

3.13.1 Valves and Equipment

Valves shall be installed at the locations shown or specified, and where required for the proper functioning of the system as directed. Gate valves shall be used unless otherwise indicated, specified, or directed. Valves shall be installed with their stems horizontal to or above the main body of the valve. Valves used with ferrous piping shall have threaded or flanged ends and sweat-type connections for copper tubing.

3.13.2 Gravity Flow-Control Valve

The valve to control the flow of water shall be installed in the supply main near the heat exchanger. The valve shall operate so that when the circulating pump starts, the increased pressure within the main will open the valve; when the pump stops, the valve will close. The valve shall be constructed with a cast iron body and shall be provided with a device whereby the valve can be opened manually to allow gravity circulation. The flow-control valve shall be designed for the intended purpose, and shall be installed as recommended by the manufacturer.

3.13.3 Thermometer Socket

A thermometer well shall be provided in each return line for each circuit in multicircuit systems.

3.13.4 Air Vents

Vents shall be installed where indicated, and on all high points and piping offsets where air can collect or pocket.

3.13.4.1 Water Air Vents

High or medium temperature water air vents shall be as indicated. Vent discharge lines shall be double-valved with globe valves and shall discharge into a funnel drain.

3.13.4.2 Steam Air Vents

Steam air vents shall be a quick-acting valve that continuously removes air. Valve shall be constructed of corrosion-resisting metal, shall be designed to withstand the maximum piping system pressure, and shall automatically close tight to prevent escape of steam and condensate. Vent shall be provided with a manual isolation valve. A vent shall be provided on the shell of each steam heat exchanger.

3.14 STEAM TRAPS

Float Traps shall be installed in the condensate line as indicated. Other steam traps shall be installed where indicated.

3.15 UNIT HEATERS

Unit heaters shall be installed as indicated and in accordance with the manufacturer's instructions.

3.16 INSULATION

Thickness of insulation materials for piping and equipment and application shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.17 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installation, adjustment, and testing of the equipment.

3.18 TESTING AND CLEANING

Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls.

3.18.1 Pressure Testing

Notify the Contracting Officer 7 days before the tests are to be conducted. The tests shall be performed in the presence of the Contracting Officer. Furnish all instruments and personnel required for the tests. Electricity, steam, and water will be furnished by the Government. All test results shall be accepted before thermal insulation is installed. The entire low temperature heating system, including heat exchanger, radiators and fittings, shall be hydrostatically tested and proved tight under a pressure of 310 kPa (45 psig) for a period of four hours.

3.18.2 Test of Backflow Prevention Assemblies

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.18.3 Cleaning

After the hydrostatic and backflow prevention tests have been made and prior to the operating tests, the heat exchanger and piping shall be thoroughly cleaned by filling the system with a solution of 0.5 kg (1 pound) of caustic soda or 0.5 kg (1 pound) of trisodium phosphate per 200 L (50 gallons) of water. Observe the proper safety precautions in the handling and use of these chemicals. The water shall be heated to approximately 66 degrees C (150 degrees F), and the solution circulated in the system for a period of 48 hours, then drained and the system thoroughly flushed out with fresh water. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. The Contractor will be responsible for maintaining the system in a clean condition until final acceptance. Bearings shall be lubricated with oil or grease as recommended by the manufacturer.

3.18.4 Water Treatment Testing

Identify in the water quality test report the chemical composition of the heating water. The report shall include a comparison of the condition of the water with the chemical company's recommended conditions. Any required corrective action shall be documented within the report. The heating water shall be analyzed prior to the acceptance of the facility and a minimum of once a month for a period of one year by the water treatment company. The analysis shall include the following information recorded in accordance with ASTM D596.

Date of Sample	
Temperature	degrees C (F)
Silica (SiO2)	ppm (mg/1)
Insoluble	ppm (mg/1)
Iron and Aluminum Oxides	ppm (mg/1)
Calcium (Ca)	ppm (mg/1)
Magnesium (Mg)	ppm (mg/1)
Sodium and Potassium (Na and K)	ppm (mg/1)
Carbonate (HCO3)	ppm (mg/1)
Sulfate (SO4)	ppm (mg/1)
Chloride (C1)	ppm (mg/1)
Nitrate (NO3)	ppm (mg/1)
Turbidity	unit
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	ppm (meq/1)
Noncarbonate Hardness	epm (meq/1
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	microsiemens/cm

3.19 FRAMED INSTRUCTIONS

Submit proposed diagrams, instructions, and other sheets, prior to posting. Show in the instructions wiring and control diagrams and complete layout of the entire system. The instructions shall include, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system. Post framed instructions, containing wiring and control diagrams under glass or in laminated plastic, where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. Post the framed instructions before acceptance testing of the system.

3.20 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Provide training for a total period of 8 hours of normal working time starting after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the approved Operation and Maintenance Manuals. Submit one hard copy & one digital copy (.pdf - text searchable) of the operation and maintenance manuals for the equipment furnished. One complete set, prior to performance testing and the remainder upon acceptance. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals shall list routine maintenance procedures, water treatment procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout and simplified wiring and control diagrams of the system as installed. Manuals shall be provided prior to the field training course.

3.21 TESTING, ADJUSTING AND BALANCING

Except as specified herein, testing, adjusting, and balancing shall be in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

-- End of Section --

SECTION 23 63 00.00 10

COLD STORAGE REFRIGERATION SYSTEMS
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 420	(2008) Performance Rating of Forced-Circulation Free-Delivery Unit Coolers for Refrigeration
AHRI 450	(2007) Water-Cooled Refrigerant Condensers, Remote Type
AHRI 490 I-P	(2011) Performance Rating of Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers
AHRI 700	(2014; Appendix C & D 2014) Specifications for Fluorocarbon Refrigerants
AHRI 710 I-P	(2009) Performance Rating of Liquid-Line Driers
AHRI 711	(2009) Performance Rating of Liquid-Line Driers
AHRI 720	(2002) Refrigerant Access Valves and Hose Connectors
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 495	(2005) Performance Rating of Refrigerant Liquid Receivers
ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units
ANSI/AHRI 750	(2007) Thermostatic Refrigerant Expansion Valves
ANSI/AHRI 760	(2007) Performance Rating of Solenoid Valves for Use With Volatile Refrigerants

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 23.1	(2010) Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant
ASHRAE 64	(2011) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems
ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A334/A334M	(2004a; R 2010) Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B280	(2013) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM C534/C534M	(2014) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM F104	(2011) Standard Classification System for Nonmetallic Gasket Materials

INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION (IIAR)

IIAR 2	(2008; ADD A 2010) American National Standard for Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2014) Motors and Generators
NEMA MG 2	(2014) Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

UNDERWRITERS LABORATORIES (UL)

UL 207	(2009; Reprint Jun 2014) Refrigerant-Containing Components and Accessories, Nonelectrical

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1002	(2001) Hexagon Head Bolts and Hexagon Head Screws
KS B 5305	(2008) Bourdon Tube Pressure Gauges
KS D 3503	(2008) Rolled Steels for General Structure
KS D 3506	(2007) Hot-Dip Zinc Coated Steel Sheets and Coils
KS D 3515	(2012) Rolled Steel for Welded Structures
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 6701	(2012) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6763	(2007) Aluminium and aluminium alloy rods, bars and wires

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

SD-03 Product Data

Refrigeration System; G
Spare Parts
Framed Instructions
Qualifications; G
Verification of Dimensions
Coil Corrosion Protection
Tests
Demonstrations; G

SD-06 Test Reports

Tests; G

SD-07 Certificates

Refrigeration System
Service Organizations

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit a letter listing the qualifying procedures for each welder including supporting data such as test procedures used, what was tested to, etc. and a list of the names of qualified welders and their identification symbols. Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record. Welding and nondestructive testing procedures shall be as specified in Section 40 05 13.96 WELDING PROCESS PIPING. Weld structural members in accordance with Section 05 05 23 WELDING, STRUCTURAL.

1.3.2 Drawings

Investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Equipment, ductwork, and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Submit drawings providing adequate detail to demonstrate compliance with contract requirements and consisting of:

(1) Equipment layouts identifying assembly and installation details.

(2) Piping layouts which identify valves, fittings, pipe sizes, and pipe slopes. Clearly identify and explain any changes to the design.

(3) Plans and elevations which identify clearances required for maintenance and operation.

(4) Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

(5) Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for equipment indicated or required to have concrete foundations.

(6) Details of supports, if other than those indicated, including loadings and type of frames, brackets, stanchions, or others.

(7) Automatic temperature control diagrams and control sequences.

(8) Installation details which include the amount of factory set superheat and corresponding refrigerant pressure/temperature.

1.3.3 Service Organizations

Submit a certified list of qualified permanent service organizations for the specified equipment, as specified. Include their addresses and qualifications, for support of the specified equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather and contamination. Proper protection and care of material before, during, and after installation is the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 MAINTENANCE

1.5.1 Operation Manual

Provide one hard copy & one digital copy (.pdf - text searchable) of an operation manual listing step-by-step procedures required for system startup, operation, and shutdown. The booklets shall include the manufacturer's name, model number, parts list, and a brief description of all equipment and their basic operating features.

1.5.2 Maintenance Manual

Provide one hard copy & one digital copy (.pdf - text searchable) of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and a troubleshooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

1.5.3 Extra Materials

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than one month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use includes applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including compressors, condensers, unit coolers, receivers, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics and enclosure type shall be as shown, and unless otherwise indicated, motors of 746 W (1 horsepower) and above with open, drip-proof, or totally enclosed fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. Unit control panels and electrical components shall be mounted in a NEMA ICS 6, Type 1 or 3A enclosure.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Refrigerant and Oil

Refrigerant shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. Refrigerants shall meet the requirements of AHRI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential of less than or equal to 0.05 Refrigerant systems shall be charged in accordance with manufacturer's recommendations, including types and quantities of refrigerant and lubricating oil. Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the system performance testing period. Following the satisfactory completion of the performance testing, the oil shall be drained and replaced with a second charge.

2.4.2 Gaskets

Gaskets shall conform to ASTM F104 classification for compressed sheet with nitrile binder and acrylic fibers for maximum 370 degrees C (700 degrees F) service.

2.4.3 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall conform to ASTM A307 or KS B 1002. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies, in accordance with ASTM A307 or KS B 1002.

2.4.4 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.4.5 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.4.6 Pressure and Vacuum Gauge

Gauge shall conform to ASME B40.100, Class 1, 2, or 3, Style X, Type I or III or KS B 5305 as required, 115 mm (4-1/2 inches) in diameter with phenolic or metal case. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle third of the range.

2.4.7 Temperature Gauges

Industrial duty thermometers shall be provided for the required temperature range. Thermometers shall have a Fahrenheit scale on a white face. The pointer shall be adjustable.

2.4.7.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube.

2.4.7.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.4.7.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.4.7.4 Thermal Well

Thermal well shall be identical size, 13 or 19 mm (1/2 or 3/4 inch) NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 13 mm (1/2 inch) NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm (1 inch).

2.4.8 Unicellular Plastic Foam

Unicellular plastic foam shall be in accordance with ASTM C534/C534M, Type I.

2.4.9 Bird Screen

Screen shall be square mesh, plain weave, 2 by 2 mesh, 1.6 mm (0.063 inch) diameter aluminum wire or 0.79 mm (0.031 inch) diameter stainless steel wire.

2.4.10 Galvanized Steel Sheet

ASTM A653/A653M, Coating Class G-90 or KS D 3506, lockforming quality.

2.4.11 Galvanized Steel Shapes

ASTM A36/A36M, KS D 3503, or KS D 3515 to commercial weight of not less than 0.70 kg/square meter (2.3 ounces/square foot) of single side surface.

2.4.12 Aluminum Sheets and Plates

ASTM B209M (ASTM B209), Alloy 3003, H-14 or KS D 6701. Sheets shall be lockforming quality.

2.4.13 Aluminum Shapes

ASTM B221M (ASTM B221), Alloy 6061, T-5 and T-6 or KS D 6763.

2.5 COMPRESSOR/CONDENSING UNITS

Compressor or condensing unit shall be factory fabricated, assembled, tested, packaged, and ready for full capacity operation after terminal point connection and field charging with operating fluids. Unit shall conform to ANSI/AHRI 520, ASHRAE 23.1, and ANSI/ASHRAE 15 & 34.

2.5.1 Compressor

Select compressors for maximum energy efficiency and operating reliability. Rotating parts shall be statically and dynamically balanced at the factory to eliminate vibration at both partial and full load conditions. Compressors shall be capable of continuous operation at lowest partial load. Compressor over 7.5 kW (10 hp) shall start from rest unloaded. Compressor unloaders shall not be used when saturated suction temperatures are below minus 4 degrees C (25 degrees F).

2.5.1.1 Construction

Compressors 1.5 kW (2 hp) and less shall be the accessible, sealed reciprocating type of either the open or hermetic design. Compressors above 1.5 kW (2 hp) shall be the accessible hermetic, sealed reciprocating type. Compressors shall have integrally cast housings of close-grained iron with an oil-level bull's eye, cast cylinder heads, cast aluminum or forged steel connecting rods, and cast iron or forged steel crankshafts. Main bearings shall be the sleeve-insert type.

2.5.1.2 Lubrication System

The lubrication system on compressors 2.2 kW (3 hp) or larger shall be the forced-feed, positive-displacement type with oil strainer. The oil pump shall be reversible. Lube oil pressure gauge and failure switch shall be provided for forced-feed lubrication type compressors. Compressor shall be provided with an adjustable oil level regulator with a shutoff valve on each inlet to allow removal of individual compressors without shutting down the entire system.

2.5.1.3 Motor

Compressor motors shall be of the constant-speed, squirrel-cage, induction, hermetically sealed, low-starting-current, high-torque type. Motors shall be furnished with magnetic NEMA across-the-line motor starters in general purpose enclosures.

2.5.1.4 Compressor Components

Compressor systems shall include, as a minimum, the following:

a. Compressors 1.1 kW (1-1/2 hp) and larger shall be provided with double seated suction and discharge service valves each with gauge ports.

b. Compressors 3.7 kW (5 hp) or larger shall have a solid state oil pressure safety switch with a manual reset with auxiliary alarm contacts. Time delay duration shall be as recommended by compressor manufacturer.

c. Each compressor shall have a single low-pressure control with automatic reset and adjustable cut-in and cut-out range. Braided steel lines shall be used.

d. Each compressor shall have a single high-pressure control with manual reset, adjustable set-point, and auxiliary alarm contact. Braided steel lines shall be used.

e. A compressor cooling fan shall be provided for each compressor which operates below minus 18 degrees C (0 degrees F) saturated suction temperature.

f. Each compressor shall have a crankcase oil heater. Control of the heaters shall be as recommended by the compressor manufacturer.

g. When required by the compressor manufacturer, compressors shall be provided with a hot-gas muffler to reduce vibration and noise from pulsations.

2.5.2 Base Mounting

Factory mount compressor and accommodating components on a rigid, steel base where indicated. Mount the compressor assembly with spring type vibration isolation mountings Mass of the concrete inertia block shall be 2.0 times mass of supported assembly. Spring mountings shall be selected to limit transmissibility of imbalanced forces at lowest equipment rpm to 3 percent.

2.5.3 Unit Accessories

Integral or remote condensers shall be in accordance with paragraph CONDENSER. Accessories to be used in combination with each unit shall be provided as indicated and shall be in accordance with paragraph REFRIGERANT ACCESSORIES. Outdoor condensing units shall be provided with weather hoods.

2.5.4 Electrical Controls

Electrical controls for the unit shall be in accordance with paragraph ELECTRICAL WORK and include at a minimum main and branch circuit overload protective devices compensated for ambient temperatures as recommended by the manufacturer; status pilot lights; compressor safety, operating and capacity controls; defrost controls; local and remote audible and visual alarms with provisions to silence; short cycling control with lock-out timer; time delay for sequenced compressor starts; and remote component interface.

2.6 CONDENSER, AIR-COOLED

Unit shall be factory fabricated and tested, packaged, self-contained and ready for full capacity operation after terminal point connections. Unit shall conform to ANSI/AHRI 460. Split systems shall be manufacturer matched units. Fans shall be propeller or centrifugal type as specified in paragraph Fans. Fan motors shall have totally enclosed enclosures. Electrical controls for the unit shall be in accordance with paragraph ELECTRICAL WORK shall include a control transformer and shall be capable of interfacing with local and remote components.

2.6.1 Unit Casing

Casing shall be weatherproof and enclose all unit components. Structural members and sheet metal for the unit casing shall be constructed of galvanized steel or aluminum. Casing shall be fitted with lifting provisions, access panels, removable legs, and fan and heat rejection coil guards and screens.

2.6.2 Condenser Coil

Coil shall have copper or aluminum tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and shall be suitable for the working pressure of the installed system. Condenser may be used for refrigerant storage in lieu of separate receiver, provided that storage capacity is 20 percent in excess of fully charged system. Coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.7 CONDENSER, WATER-COOLED

Condenser shall be remote mounted, tested and rated to AHRI 450 and an integral component of a water-cooled condensing unit, be tested and rated to ANSI/AHRI 520. Condensers shall have safety provisions conforming to ANSI/ASHRAE 15 & 34. Coils shall conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Condenser heads shall be removable and have flanged side inlet pipe connections which permit access to or removal of the tubes. A separate condenser shall be provided for each compressor circuit. Fans shall be propeller or centrifugal type as specified in paragraph Fans. Fan motors shall have totally enclosed enclosures, unless otherwise indicated.

2.7.1 Unit Casing

Casing shall be weatherproof and enclose all unit components. Structural members and sheet metal for the unit casing shall be constructed of galvanized steel or aluminum. Casing shall be fitted with lifting provisions, access panels, removable legs, and fan and heat rejection coil guards and screens.

2.7.2 Condenser Coil

Condensers shall be of the shell-and-tube type with the coolant in the tubes. Water-wetted metals shall be copper or 90/10 or 70/30 copper-nickel, except that heads may be ferrous metal in systems with chemically treated recirculating water. Unit shall be rated for not less than 2758 kPa (400 psig) refrigerant side and 860 kPa (125 psig) water side pressure service at operating temperatures. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) nor more than 3 m/s (10 fps) with a fouling factor of 0.0005. The design pressure drop shall govern the number of passes. Control valve(s) on the water supply line shall be the automatic, self-contained type, controlled by condensing pressure which close bubble-tight when compressor is not operating or the modulating three-way type, controlled by pressure controller.

2.8 CONDENSER, EVAPORATIVE

Each unit shall be the counter-flow blow-through design, with single-side air entry. The unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 1.6 mm (16 gauge) steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153/A153M and ASTM A123/A123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square m (2-1/2 ounces per square foot) of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit. Unit shall be rated in accordance with AHRI 490 I-P and tested in accordance with ASHRAE 64.

2.8.1 Pan Section

The pan shall be watertight and shall be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.8.2 Fan Section

Fan shall be the centrifugal or propeller type in accordance with paragraph Fans. Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have totally enclosed enclosure, unless otherwise indicated, and shall be suitable for the indicated service. The condensing unit design shall prevent water from entering into the fan section.

2.8.3 Condensing Coil

Coils shall have copper or aluminum tubes of 10 mm (3/8 inch) minimum diameter without fins. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged.

2.8.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and shall be arranged for easy access.

2.8.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pumps shall have cast iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have totally enclosed enclosures, unless otherwise indicated. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.8.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.9 UNIT COOLERS

Unit shall be forced circulation free delivery type, factory fabricated, assembled and tested, and packaged in accordance with AHRI 420. Fan shall be the centrifugal or propeller type in accordance with paragraph Fans. Motors shall have totally enclosed enclosures, unless otherwise indicated.

2.9.1 Construction

Casing shall be Type 300 stainless steel, aluminum, mill galvanized or hot-dip galvanized steel after fabrication. Zinc-coated carbon steel shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Coils shall have copper tubes and aluminum fins. Drain pan shall be watertight, corrosion resistant. Drainage piping for units in spaces maintained at less than 2 degrees C (35 degrees F) shall be insulated.

2.9.2 Defrosting

Unit shall be defrosted with ambient space airor fitted with a hot gas or electric heat defrosting system, as indicated in contract drawings. Defrost system shall be controlled by timer defrost controller adjustable for up to 6 defrost cycles per 24 hours, each of 5 to 120 minutes duration. Controller shall include an adjustable timer to control frequency of cycles; defrost initiating thermostat; adjustable program timer to control sequence of defrost cycle; defrost terminating thermostat; manual override switch; selector switch; and status pilot light. Defrost system shall be controlled by demand defrost controller.

Controller shall include an automatic, solid-state circuitry to initiate defrost cycle based on sensing adjustable temperature difference of air moving across coil in direct proportion to frost build-up; thermostat to terminate defrost; adjustable lockout to prevent initiation of defrost during pull-down after defrost cycle; manual override switch; and status pilot light.

2.10 CONTROLS AND INSTRUMENTS

Refrigeration system controls, instruments and devices shall be industrial quality, and shall conform to applicable requirements of ANSI/ASHRAE 15 & 34. Submit manufacturer's standard catalog data, prior to the purchase or installation of a particular component, highlighted to show brand name, model number, size, options, performance charts and curves, etc. in sufficient detail to demonstrate compliance with contract requirements.

a. Provide data for each specified component including manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, include vibration isolator literature containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

b. Fluid containing surfaces shall be rated for the service and constructed of materials suitable for the fluid. Component electrical rating shall be 120 volt ac, unless otherwise indicated and shall be suitable for imposed loads.

c. Submit proof of compliance where the system, components, or equipment are specified to comply with requirements of AHRI, ASHRAE, ASME, or UL. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted.

d. When performance requirements of this project's drawings and specifications vary from standard AHRI rating conditions, computer printouts, catalog, or other application data certified by AHRI or a nationally recognized laboratory as described above shall be included. If AHRI does not have a current certification program that encompasses such application data, the manufacturer may self certify that its application data complies with project performance requirements in accordance with the specified test standards.

2.10.1 Refrigeration System Alarms

2.10.1.1 Audible Alarm

Audible alarm shall be surface-mounted, 100 mm (4 inch) vibrating bell type suitable for indoor or outdoor service.

2.10.1.2 Visual Alarm

Visual alarm shall be pilot light type. Alarm shall be 100 watt, incandescent, vapor-tight fixture with cast metal guard and red, green, or amber lens.

2.10.2 Controllers

2.10.2.1 Differential Pressure Controller

Differential pressure controller shall be provided with high and low pressure sensing ports and shall be direct or reverse acting with calibrated proportional band and set point adjustments. Controller output shall be low voltage electric, proportional to the pressure differential sensed. Local and remote set point adjustments shall be included. Range shall meet system requirements.

2.10.2.2 Differential Temperature Controller

Differential temperature controller shall be provided with two filled, remote sensing bulbs connected to the controller by capillary or armored capillary tubing, as indicated. Controller shall be direct or reverse acting with calibrated proportional band and set point adjustments. Controller output shall be low voltage electricor 4-20 mA dc, as indicated in contract drawings, proportional to the temperature differential sensed. Provisions for local and remote set point adjustments shall be included. Range shall be as required to meet system requirements. For immersion service, thermal wells shall be provided.

2.10.3 Pilot Lights

Panel-mounted pilot lights shall be NEMA Class 12 oil-tight, push-to-test transformer for 6-8 Vac lamps. Lamps shall be replaceable by removal of color cap. Cap color shall be as indicated.

2.10.4 Programmer, Demand Control/Load

Programmer shall be fully automatic, fail safe, field programmable, solid-state, demand control and load programmable for 16 loads,or the number of loads indicated on drawings, whichever is greater. Demand control portion shall monitor power consumption by watt or current transducers. Set point shall be field adjustable with adjustable dead band. Load shedding sequence time and differential time between load shedding shall be adjustable. Contacts shall store alarm condition. Meter readout shall indicate demand deviation from set point. Load profile recorder shall be strip-chart type with readily discernible event record. Load programmer shall permit programming of on/off time of each load for any time element within a week and shall equalize power demand over a preset time cycle. System shall include input override and time cycle accelerator for checkout. Alarm condition, status of all loads and time period shall be visually indicated and recorded. Each load shall include a H-O-A toggle switch. Alarm provisions shall include relay contacts for external, remote alarm functions and test provisions. Override thermostat, pressure switch, or timer shall be provided to restore loads that have been shed as indicated. Control panel enclosure shall be NEMA ICS 6, Type 1, surface mounted type with key lock. Load profile recorder shall be flush panel mounted type, unless otherwise indicated. Load relays shall be plug-in type with critical load failure in "on" mode and contacts rated for pilot duty at 120 volt ac. Load shedding position switches shall shed loads on a first shed/last restore basis and remove loads from system logic for shedding cycle. Time clock shall be fitted with spring motor to maintain time in event of power failure.

2.10.5 Switches, Fluid Service

Switches shall be field adjustable SPDT type and shall have NEMA ICS 6, Type 1 enclosure with operating range specified or indicated. Circuits shall be as required for the applicable functions.

2.10.5.1 Air Flow Switch

Air flow switch shall have a service pressure range of 31 to 2542 Pa (0.12 to 10 inches wg).

2.10.5.2 Water-Flow Switch

Water flow switch shall have a body rating suitable for the service, field-adjustable activating flow rate, and a pressure drop not in excess of 13.8 kPa (2 psi) at maximum flow rate.

2.10.5.3 Pressure Switch

Pressure switch shall be factory set, one or two stage as indicated, with adjustable operating and differential pressure. Bourdon tube inlet shall be fitted with damper screw adjustment.

2.10.5.4 Differential Pressure Switch

Differential pressure switch shall be factory set, provided with high and low sensing ports, one or two stages and adjustable differential range and pressure.

2.10.5.5 Temperature Switch

Temperature switch shall be factory set, provided with armored capillary tubing, unless otherwise indicated and filled sensing system, one or two stages as indicated, and operating adjustable differential range. For immersion service, thermal wells shall be provided.

2.10.5.6 Differential Temperature Switch

Differential temperature switch shall be factory set, provided with two separate or separate armored capillary systems, one or two stages, and adjustable differential range and temperature. For immersion service, thermal wells shall be provided.

2.10.6 Push-Button Stations

Stations shall be NEMA Class 12 oil-tight, momentary or maintained-contact type, as indicated. Start push-buttons shall have a fully guarded or flush black operator button. Stop push-buttons shall have an unguarded or extended red operator button.

2.10.7 Selector

Switches shall be NEMA Class 12 oil-tight, momentary or maintained contact type, as indicated, with standard operator.

2.11 HEAT RECOVERY DEVICES

2.11.1 Heat Recovery Coil, Air

Coil shall be compatible with the type of refrigerant used in the system. Coil shall have copper or aluminum tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and shall be suitable for the working pressure of the installed system. Coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Coil shall mount within a heat recovery, factory-fabricated, draw-through, central station type air conditioner in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.11.2 Hot Water Reclaim

Unit shall be a double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit shall be constructed and refrigerant pressure/temperature rated in accordance with ANSI/ASHRAE 15 & 34. Heat exchanger coil shall consist of an external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet shall be fabricated of zinc-protected steel and shall be internally insulated in coil space. The recovery device shall be provided with a refrigerant compressor head pressure control and an interlocked, potable water circulating pump. Pump and motor assembly shall be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump shall be mounted remotely or integral to the exchanger and be rated for 115, 208, or 230 volt ac power supply, as indicated on contract drawings.

2.12 PURGE SYSTEM

Provide refrigeration systems, which operate at pressures below atmospheric pressure, with a purge system. Purge systems shall automatically remove air, water vapor, and non-condensible gases from the system's refrigerant. Purge systems shall condense, separate, and return all refrigerant back to the system. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into the system.

2.13 REFRIGERANT LEAK DETECTOR

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include a single sampling point installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant. Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay should be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be compatible with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.14 REFRIGERANT RELIEF VALVE/RUPTURE DISC ASSEMBLY

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC IX and ANSI/ASHRAE 15 & 34. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.15 REFRIGERANT SIGNS

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 13 mm (0.5 inches) in height.

2.15.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name
b. Refrigerant number and amount of refrigerant.
c. The lubricant identity and amount.
d. Field test pressure applied.

2.15.2 Controls and Piping Identification

Provide refrigerant systems containing more than 50 kg (110 lb) of refrigerant with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow, the ventilation system, and the refrigerant compressor.

b. Pressure limiting device.

2.16 POWER TRANSMISSION COMPONENTS

Fan and open compressor drives shall be in accordance with the manufacturer's published recommendations, except as otherwise specified. Horsepower rating of V-belt drive shall be based on maximum pitch diameter of sheaves. Compressors shall be fitted with fixed sheaves and drives with a minimum service factor of 1.5. Where the number of unit starts exceeds 8 per 24 hours, add 0.1 to the required drive service factor. Sheaves shall be statically and dynamically balanced, machined ferrous metal, bushing type, secured by key and keyway. Pitch diameter of fixed pitch sheaves and adjustable sheaves, when adjusted to specific limits, shall be not less than that recommended by NEMA MG 1. Adjustable sheaves shall be selected to provide the required operating speed with the sheave set at mid-point of its adjustment range. The adjustment range for various size and type belts shall be 16 percent minimum for classical section belts and 12 percent minimum for narrow section belts. Belt drive motors shall be provided with slide rail or equivalent adjustable motor bases. Direct drive couplings for motors rated less than 2.2 kW (3 hp) shall be manufacturer's standard. Direct drive couplings for motors rated greater than 2.2 kW (3 hp) shall be elastomer-in-shear type. Each drive shall be independent of any other drive. Drive bearings shall be protected with water slingers or shields. V-belt drives shall be fitted with guards where exposed to contact by personnel.

2.17 CONDENSER WATER SYSTEMS

Cooling towers, condenser water pumps, condenser water treatment systems, condenser water piping, fittings, valves and accessories shall be in accordance with Sections 23 65 00 COOLING TOWER and 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.18 DRAIN AND MISCELLANEOUS PIPING

Piping, fittings, valves and accessories for drain and miscellaneous services shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.19 PIPING AND FITTINGS, FLUOROCARBONS

Piping, valves, fittings, and accessories shall conform to the requirements of ANSI/ASHRAE 15 & 34and ASME B31.5, except as specified.

2.19.1 Steel Pipe

Steel pipe for fluorocarbon service shall conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B or KS D 3562. Type F pipe shall not be used.

2.19.2 Steel Pipe Joints and Fittings

Joints and fittings shall be steel butt-welding, socket-welding, or malleable iron threaded type. Pipe shall be welded except that joints on lines 50 mm (2 inches) and smaller may be threaded. Threads shall be tapered type conforming to ASME B1.20.2M (ASME B1.20.1). The malleable iron threaded type fitting shall be of a weight corresponding to adjacent pipe. Flanges and flange faces of fittings shall be tongue-and-groove type with gaskets suitable for the refrigerant used; size 25 mm (1 inch) and smaller shall be oval, two-bolt type; size above 25 mm (1 inch), up to and including 100 mm (4 inch), shall be square four-bolt type; and sizes over 100 mm (4 inch) shall be round.

2.19.3 Steel Tubing

Steel tubing for refrigeration service shall be in accordance with ASTM A334/A334M, Grade 1. Tubing with a nominal diameter of 10 mm (3/8 inch) or 13 mm (1/2 inch) shall have a wall thickness of 1.22 mm (0.049 inches). Tubing with a nominal diameter of 19 mm (3/4 inch) through 50 mm (2 inches) shall have a wall thickness of 1.62 mm (0.065 inches). Tubing with a nominal diameter of 65 through 100 mm (2-1/2 through 4 inches) shall have a wall thickness of 2.4 mm (0.095 inches). Steel tubing shall be cold-rolled, electric-forged, welded-steel. One end of the tubing shall be provided with a socket. Steel tubing shall be cleaned, dehydrated, and capped.

2.19.4 Steel Tubing Joints and Fittings

Joints and fittings shall be socket type provided by the steel tubing manufacturer.

2.19.5 Copper Tubing

Copper tubing shall conform to ASTM B280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm (1-3/8 inches). Joints shall be brazed except that joints on lines 22 mm (7/8 inch) and smaller may be flared.

2.19.6 Copper Tube Joints and Fittings

Copper tube joints and fittings shall be flare joint type with short-shank flare, or solder-joint pressure type. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings will not be allowed for brazed joints.

2.20 VALVES FLUOROCARBON

Valves shall be pressure and temperature rated for contained refrigerant service and shall comply with ASME B31.1. Metals of construction shall be of Type 300 stainless steel, or ferrous or copper based. Atmosphere exposed valve stems shall be stainless steel or corrosion resistant metal plated carbon steel. Valve body connections shall be brazed or welded socket, flanged or combination thereof. Threaded connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Valves shall be suitable for or fitted with extended copper ends for brazing in-place without disassembly. Ferrous body valves shall be fitted with factory fabricated and brazed copper transitions. To minimize system pressure drops, where practicable, globe valves shall be angle body type, and straight line valves shall be full port ball type. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by manufacturer. Valves shall be cleaned and sealed moisture-tight.

2.20.1 Refrigerant-Stop Valves

Stop valves shall be designed for use with the refrigerant used and shall have pressure ratings compatible with system working pressures encountered. Gate valves will not be acceptable.

2.20.1.1 Fluorocarbon Service

Valves 16 mm (5/8 inch) and smaller shall be handwheel operated, straight or angle, packless diaphragm globe type with back-seating stem, brazed ends, except where SAE flare or retained seal cap connections are required. Valves larger than 16 mm (5/8 inch) shall be globe or angle type, wrench operated with ground-finish stems, or ball valves, packed especially for refrigerant service, back seated, and provided with seal caps. Refrigerant isolation and shutoff valves shall have retained or captive spindles and facilities for tightening or replacement of the gland packing under line pressure as applicable. Stop valves shall have back-seating plated steel stem, bolted bonnet in sizes 25 mm (1 inch) OD and larger, integral or flanged transition brazed socket. Valves, in sizes through 65 mm (2-1/2 inches) shall be end-entry body assembly, full-port, floating ball type, with equalizing orifice fitted chrome plated ball, seats and seals of tetrafluoroethylene, chrome plated or stainless steel stem, and seal cap. In sizes 100 mm (4 inch) IPS and larger, and in smaller sizes where carbon steel piping is used, valve bodies shall be tongue and groove flanged and complete with mating flange, gaskets and bolting for socket or butt-weld connection. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.20.2 Check Valve

Valve shall be designed for service application, spring-loaded type where required, with resilient seat and with flanged body in sizes 13 mm (1/2 inch) and larger. Valve shall provide positive shutoff at 10.3, 13.8, or 20.7 kPa (1-1/2, 2, or 3 psi) differential pressure.

2.20.3 Liquid Solenoid Valves

Valves shall comply with ANSI/AHRI 760 and shall be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2758 kPa (400 psi) and a maximum operating pressure differential of at least 1380 kPa (200 psi) at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.20.4 Expansion Valves

Expansion valves shall conform to the requirements of ANSI/AHRI 750. Valve shall be of the diaphragm and spring type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 degree C (2 degrees F) of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and liquid shall remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads. In direct-expansion unit cooler applications, thermostatic expansion valve discharge shall be through distributor and distributing tubes or through a single tube outlet leading to an orificed header provided by the unit cooler manufacturer, supplying an evaporator coil with not more than four circuits. Distributor orifices shall be sized for application conditions and distributor shall be provided by the thermostatic expansion valve manufacturer as a matched combination to suit evaporator coil circuitry. Where indicated, distributor tube shall be fitted with side inlet for hot gas bypass or defrosting. In single compressor/evaporator combinations, where compressor capacity control is only by on-off cycling, and if recommended by the compressor manufacturer, thermostatic expansion valve shall be furnished with a small bleed passage between inlet and outlet to facilitate equalization of high and low side during off cycle.

2.20.5 Safety Relief Valve

Valve shall be the two-way type, unless otherwise indicated. Single type valves shall be used only where indicated. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.20.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring power assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degree C (2 degrees F) change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.20.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall conform to AHRI 720.

2.20.8 Service Gauge Fittings

Fittings shall be designed for connecting a pressure gauge with a hose fitting. These fittings shall be provided in the suction pipe at each unit cooler.

2.21 REFRIGERANT ACCESSORIES

2.21.1 Fans

Fan wheel shafts shall be supported by either maintenance-accessible lubricated anti-friction block-type bearings, or permanently lubricated ball bearings. Unit fans shall be selected to produce the cfm required at the fan total pressure. Thermal overload protection shall be of the manual or automatic-reset type. Fan wheels or propellers shall be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings shall be of galvanized steel, and both centrifugal and propeller fan casings shall be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, shall be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting shall be recoated with an approved zinc-rich compound. Fan wheels or propellers shall be statically and dynamically balanced. Direct-drive fan motors shall be of the multiple-speed variety. Centrifugal scroll-type fans shall be provided with streamlined orifice inlet and V-belt drive. Each drive shall be independent of any other drive. Propeller fans shall be direct-drive or V-belt drive type with adjustable or fixed pitch blades. V-belt driven fans shall be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated anti-friction block-type bearings, or permanently lubricated ball bearings.

2.21.2 Pressure Vessels

Pressure vessels shall conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, pressure components shall be tested at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces shall be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed. Where service temperatures below minus 6.7 degrees C (20 degrees F) are encountered, materials of construction shall be low temperature alloy carbon steel.

2.21.2.1 Hot Gas Muffler

Unit shall be selected by the manufacturer for maximum noise attenuation. Units rated for 105.5 kW (30 tons) capacity and under may be field tunable type.

2.21.2.2 Liquid Receiver

Receiver shall be designed, filled, and rated in accordance with the recommendations of ANSI/AHRI 495, except as modified herein. Receiver shall be sized so that it is never filled beyond 80 percent of its total capacity. The remaining 20 percent shall allow for liquid expansion. Receiver shall be provided with a relief valve of capacity and setting in accordance with ANSI/ASHRAE 15 & 34. Receiver shall be fitted to include an inlet pipe; an outlet drop pipe with oil seal and oil drain where necessary; two bulls-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves; a thermal well for thermostat;, a float switch column;, or external float switches; purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver shall be factory insulated with not less than 25 mm (1 inch) thick, 100 percent adhesive bonded, vaportight, flexible, closed-cell elastomer and finished with two coats of solvent base PVC protective coating or 0.41 mm (0.016 inch) thick aluminum jacket.

2.21.2.3 Oil Separator

Separator shall be the high efficiency type, provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator shall not exceed 69 kPa (10 psi) during the removal of hot gas entrained oil. Connections to compressor shall be as recommended by the compressor manufacturer. Separator shall be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass, and strainer.

2.21.2.4 Oil Reservoir

Reservoir capacity shall equal one charge of all connected compressors. Reservoir shall be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header shall be provided with a 34.5 kPa (5 psi) pressure differential relief valve. Reservoir shall be provided with the manufacturer's standard filter on the oil return line to the oil level regulators.

2.21.3 Condenser and Head Pressure Control

Unit shall be capable of automatically operating without daily or seasonal adjustments in ambient temperature of 105 degrees C (221 degrees F). Control shall be set for refrigerant condensing temperature of 100 degrees C (212 degrees F). Controls shall permit proper operation of system with proper differential pressure across the thermostatic expansion valve. Control system shall be based on sensing of actual condensing pressure in conjunction with manufacturer's standard method of subcooling the saturated refrigerant. Controls shall be set to produce a minimum 2 degrees C (35 degrees F) subcooling. Subcooling circuit shall be liquid sealed. Air volume control will not be acceptable for ambient conditions below 2 degrees C (35 degrees F). Necessary accessories shall be provided to maintain safe compressor discharge temperatures for low temperature systems.

2.21.4 Filter Driers

Driers shall conform to AHRI 711 (AHRI 710 I-P). Sizes 16 mm (5/8 inch) and larger shall be the full flow, replaceable core type. Sizes 13 mm (1/2 inch) and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10 MPa (1,500 psig).

2.21.5 Sight Glass and Liquid Level Indicator

2.21.5.1 Assembly and Components

Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

2.21.5.2 Gauge Glass

Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.21.5.3 Bulls-Eye and Inline Sight Glass Reflex Lens

Bulls-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlit viewing shall be provided.

2.21.5.4 Moisture Indicator

Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.21.6 Flexible Pipe Connectors

Connector shall be pressure and temperature rated for the service in accordance with ANSI/ASHRAE 15 & 34 and ASME B31.5. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C (300 degrees F). Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.21.7 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y or angle pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than 10 times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.21.8 Brazing Materials

Brazing materials for refrigerant piping shall be in accordance with AWS A5.8/A5.8M, Classification BCuP-5.

2.21.9 Liquid and Suction Headers

Liquid and suction headers shall be provided on each multi-compressor system. Headers shall be sized according to manufacturer's recommendations. Each header shall be provided with service valves to permit servicing each unit cooler and forced circulation air coil. Each service valve shall have a gauge port which can be closed by back-seating the valve and a front seat which can close off the line connected to the manifold. Each service valve shall be provided with a removable, protective valve stem cap or cover.

2.21.10 Suction Accumulators

Accumulator shall be designed and installed within each suction header to provide a positive trap for liquid carry-over and to assure oil return to the compressors. An accumulator's internal liquid holding volume shall be as indicated. Design shall ensure that oil is not trapped in the accumulator.

2.22 FACTORY FINISHES

2.22.1 Coil Corrosion Protection

Provide coil with a uniformly applied epoxy electrodeposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating shall be applied at either the coil or coating manufacturer's factory. Coating process shall ensure complete coil encapsulation. Coating shall be capable of withstanding a minimum 1,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.22.2 Equipment and Components

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B117 using a 25 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.22.3 Color Coding

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

2.22.4 Color Coding Scheme

A color coding scheme for locating hidden piping shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform verification of dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work. Submit a letter, at least 2 weeks prior to beginning construction, including the date the site was visited, confirmation of existing conditions, and any discrepancies found.

3.2 INSTALLATION

Perform the work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. The design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX as applicable.

3.2.1 Equipment

Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions. Provide necessary supports for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps and similar items. Compressors shall be isolated from the building structure. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.2.3 Building Surface Penetrations

Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 1 mm (20 gauge). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm (1/2 inch) depth. Sleeves shall not be installed in structural members.

3.2.3.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve, and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed with not less than 100 mm (4 inches) of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 100 mm (4 inches) of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.3.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall provide a minimum of 6 mm (1/4 inch) all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

3.2.3.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 0.48 kg (17 ounce) copper sleeve or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and shall be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 inches) above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproof Clamping Flange: Pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproof clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameter.

3.2.3.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.2.3.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.2.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.2.5 Refrigeration Piping

Unless otherwise specified, pipe and fittings installation shall conform to the requirements of ASME B31.5. Pipe shall be cut accurately to the measurements established at the jobsite and worked into place without springing or forcing. Cutting or otherwise weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipes shall be cut square, shall have burrs removed by reaming, and be installed in a manner to permit free expansion and contraction without damage to joints or hangers. Filings, dust, or dirt shall be wiped from interior of pipe before connections are made.

3.2.5.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, or other malformations will not be accepted.

3.2.5.2 Functional Requirements

Piping shall be sloped 13 mm/3 m (1/2 inch/10 feet) of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings.

3.2.5.3 Brazed Joints

Perform brazing in accordance with AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and shall not be sprung or forced.

3.2.5.4 Threaded Joints

Threaded joints shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.2.5.5 Welded Joints

Welded joints in steel refrigerant piping shall be fusion welded. Changes in direction of piping shall be made with welded fittings only; mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. Branch connections shall be made with welding tees or forged welding branch outlets. Steel pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.2.5.6 Flanged Joints

Flanged joints shall be assembled square and tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, refrigeration equipment, control valves, and other similar items.

3.2.5.7 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.2.6 Piping Supports

Refrigerant pipe supports shall conform to ASME B31.5. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.2.6.1 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads as specified in UFC 3-310-04 SEISMIC DESIGN FOR BUILDINGS and Sections 13 48 00SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as indicated. Provide structural steel, required for reinforcement, to properly support piping, headers, and equipment but not shown. Material used for support shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.2.6.2 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in-concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Material used for support shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.2.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used.

3.2.7.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.2.7.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.2.7.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.7.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.2.7.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C (60 degrees F) or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C (60 degrees F). A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.2.7.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69. A support shall be installed not over 300 mm (12 inches) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1525 mm (5 feet) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg (50 pounds) shall have the excess hanger loads suspended from panel points.

3.2.7.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4570 mm (15 feet), not more than 2440 mm (8 feet) from end of risers, and at vent terminations.

3.2.7.8 Pipe Guides

Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.2.7.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.2.7.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches), or by an amount adequate for the insulation, whichever is greater.

3.2.7.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.2.8 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1525 mm (5 feet) on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 610 mm (2 feet) on each side of the joint.

3.2.9 Pipe Anchors

Provide anchors wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.2.10 Piping Identification

Each piping system and direction of fluid flow shall be identified in accordance with applicable provisions of ASME A13.1 with color coded, water, moisture and broad-spectrum temperature resistant, plastic labels.

3.2.11 Manual Valves

Install stop valves on each side of each piece of equipment such as compressors, condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Angle and globe valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm (1 inch). Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensible gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

3.2.12 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 50 mm (2 inches) in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 50 mm (2 inches). The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall be installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb is installed in a vertical line, the bulb tubing shall be facing up.

3.2.13 Valve Identification

Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 35 mm (1-3/8 inch) diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 1.63 mm (14 gauge) annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.2.14 Strainers

Strainers shall be provided immediately ahead of solenoid valves and expansion devices and where indicated. Strainers may be an integral part of the expansion valve.

3.2.15 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located so that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations. A dryer shall be installed so that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.16 Sight Glass

A moisture indicating sight glass shall be installed in refrigerant circuits downstream of filter dryers and where indicated. Sight glass shall be full line size.

3.2.17 Thermometers

Thermometers shall be fitted with thermal well. Mercury shall not be used in thermometers. Where test thermometer locations are indicated, only plugged thermal well shall be provided. Thermometers located within 1525 mm (5 feet) of floor may be rigid stem type. Where thermal well is located above 1525 mm (5 feet)above floor, thermometer shall be universal adjustable angle type or remote element type to 2135 mm (7 feet) above floor and remote element type where thermal well is 2135 mm (7 feet) or more above floor. Thermometers shall be located in coolant supply and return or waste lines at each heat exchanger, at each automatic temperature control device without an integral thermometer, refrigerant liquid line leaving receiver, refrigerant suction line at each unit cooler, and where indicated or required for proper operation of equipment.

3.2.18 Flexible Connectors

Flexible metallic connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required. Connectors shall be provided in the suction and discharge lines on spring mounted compressors. Connectors shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.2.19 Power Transmission Components Adjustment

V-belts and sheaves shall be properly aligned and tensioned preliminary to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct-drive couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.2.20 Unit Cooler Drainage

Drain lines from product storage spaces maintained at 2 degrees C (35 degrees F) or lower shall be fitted with NSF approved connections and cleanout tee; shall be short as possible; shall not be trapped; and shall not be combined, unless all combined units are defrosted simultaneously and are controlled by a single timer. Drain lines may be combined in spaces maintained at nonfreezing temperatures after individual trapping. Drain lines shall be heat traced and insulated starting with drain pan fitting through the surface penetration into a nonfreezing space, a distance sufficient to ensure freedom from ice during defrost cycle. Drain line size shall be not less than drain pan outlet size. Drain line shall be pitched as shown, and not less than 6 mm/300 mm (1/4 inch/foot) where not shown. Drain line heat tracing shall be electric and hot gas as indicated. Hot gas supply line to the unit cooler shall be routed in contact with the drain line by banding with all stainless steel worm drive hose clamps on not more than 300 mm (12 inch) centers and heat transfer area shall be increased by continuous tangential fillets of heat conducting paste. Electrically heat traced drain lines shall utilize external or internal to drain line heating elements, applied to produce watt-density and temperature recommended by the manufacturer. Where metallic sheathed heat tracer is used in contact with metallic drain line or internal thereto, sheath material shall be stainless steel. External metallic sheathing shall be installed by banding on not more than 300 mm (12 inch) centers with all stainless steel worm drive hose clamps and heat transfer area shall be increased by continuous tangential fillets of heat conducting paste. Electric heat tracing power supply shall be as indicated.

3.2.21 Field Applied Insulation

Field applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.22 Factory Applied Insulation

Suction headers, liquid receivers, oil separators, and oil reservoirs shall be insulated with not less than 19 mm (3/4 inch) thick unicellular plastic foam as a standard manufacturer's process.

3.2.23 Framed Instructions

Submit framed instructions for posting, at least 2 weeks prior to construction completion. Framed instructions shall be framed under glass or laminated plastic and posted where directed. Instructions shall include equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The instructions shall be posted before acceptance testing of the system.

3.3 TESTS

Submit a letter, at least 10 working days in advance of each test, advising the Contracting Officer of the test. Submit individual letters for the refrigerant system, the system performance, and the acceptance tests. Each letter shall identify the date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Utilities for testing shall be provided as specified in the SPECIAL CONTRACT REQUIREMENTS. Water and electricity required for the tests will be furnished by the Government. Provide material, equipment, instruments, and personnel required for the test.

a. The services of a qualified technician shall be provided as required to perform tests and procedures indicated. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

b. One hard copy & one digital copy (.pdf - text searchable) of each test containing the information described below. Submit individual reports for the refrigerant system, the system performance, and the acceptance tests.

(1) The dates the tests were started and completed.
(2) A list of equipment used, with calibration certifications.
(3) Initial test summaries.
(4) Repairs/adjustments performed.
(5) Final test results and comments.

3.3.1 Refrigerant System

After all components of the refrigerant system have been installed and connected, the entire refrigeration system shall be subjected to a pneumatic test as specified.

3.3.1.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.3.1.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 56.7 degrees C (minus 70 degree F) dew point and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 69 kPa (10 psig) with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ANSI/ASHRAE 15 & 34 or IIAR 2 with a maximum test pressure of 25 percent greater than specified. Pressure above 690 kPa (100 psig)shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure shall be recorded along with the ambient temperature to which the system is exposed. A correction factor of 2 kPa (0.3 psi) will be allowed for each degree change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing will not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.3.1.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 microns. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C (35 degrees F). No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 microns after the 1 hour period, the system shall be evacuated again down to 300 microns and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 microns is maintained for a period of 1 hour without the assistance of a vacuum line. If, during the testing, the pressure continues to rise, the system shall be checked for leaks, repaired as required, and the evacuation procedure repeated. During evacuation, pressures shall be recorded by a thermocouple type, electronic type, or a calibrated-micron type gauge.

3.3.1.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure, and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

3.3.1.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

3.3.1.6 Contractor's Responsibility

Take steps to prevent the release of refrigerants into the atmosphere at all times during the installation and testing of the refrigeration system. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. No more than 85 grams (3 ounces) of refrigerant shall be released to the atmosphere in any one occurrence. System leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government, including material, labor, and refrigerant, if the leak is the result of defective equipment, material, or installation.

3.3.2 System Performance

After the foregoing tests have been completed and before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's startup representative experienced in system startup and testing, at such times as directed. Tests shall cover a period of not less than 2 days for each system and demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Any refrigerant lost during the system startup shall be replaced. During the system performance tests, a report shall be maintained to document compliance with the specified performance criteria upon completion and testing of the system. The report shall include the following information at a minimum and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) The refrigerant used in the system.
(2) Condensing temperature and pressure.
(3) Suction temperature and pressure.
(4) Ambient, condensing and coolant temperatures.
(5) Running current, voltage and proper phase sequence for each phase of all motors.

c. The actual onsite setting of operating and safety controls.

d. Thermostatic expansion valve superheat-value as determined by field test.

e. Subcooling.

f. High and low refrigerant temperature switch set-points.

g. Low oil pressure switch set-point.

h. Defrost system timer and thermostat set-points.

i. Moisture content.

j. Capacity control set-points.

k. Field data and adjustments which affect unit performance and energy consumption.

l. Field adjustments and settings which were not permanently marked as an integral part of a device.

3.4 DEMONSTRATIONS

Conduct demonstrations for the operating staff as designated by the Contracting Officer. Submit a letter, at least 14 working days prior to the date of the proposed demonstrations, identifying the date, time, and location for the demonstrations which shall start after the system is functionally completed but prior to final acceptance tests. Demonstrations shall be under the direction of a registered professional engineer who shall attest to installed systems and equipment compliance with the requirements of the contract documents. Demonstrations shall include operation of systems equipment and controls through normal ranges and sequences and simulation of abnormal conditions. Each device shall be caused to function manually and automatically in accordance with its purpose. The field instructions shall cover the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.5 ACCEPTANCE TESTS

Upon completion and prior to acceptance of the work, perform pre-operational checkout, calibration and adjustment of system components to ensure and demonstrate stable, accurate, reproducible, energy efficient operation and optimum performance. Operate systems for 48 hours after all major corrections have been made. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and system shall be retested. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened.

3.6 FIELD PAINTING

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.7 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

-- End of Section --

SECTION 23 64 00

PACKAGED WATER CHILLERS, ABSORPTION TYPE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 560	(2000) Absorption Water Chilling and Water Heating Packages

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM B395/B395M	(2013) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2014) Motors and Generators

NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2015) National Fuel Gas Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

Drawings provided in adequate detail to demonstrate compliance with contract requirements, as specified.

SD-03 Product Data

Absorption Water Chiller; G

Manufacturer's standard catalog data, prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

a. Packaged Water Chiller, Absorption Type

b. Chiller Components

c. Accessories

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Posted Instructions; G

Posted instructions including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Verification of Dimensions; G

A letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

System Performance Tests; G

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Absorption water chiller - field acceptance test plan

SD-06 Test Reports

Field Acceptance Testing

Absorption water chiller - field acceptance test report

System Performance Tests

SD-07 Certificates

Absorption Water Chiller; G

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

SD-08 Manufacturer's Instructions

Water chiller - installation instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1. Fuel-fired equipment shall be in accordance with NFPA 54.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT REQUIREMENTS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. The Contractor shall submit detailed drawings consisting of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

1.6 Warranty

In addition to the warranty requirements specification in Division 00, Contract Requirements, the following major components of the chiller shall be covered by a warranty of a duration period of five years: solution pump, heat exchanger, and burner.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, water coolers, heat exchanges, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use sold-state variable-speed controllers for motors rated. 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors

2.4 CHILLER COMPONENTS

2.4.1 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, shall be provided. Tools shall be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.5 ABSORPTION WATER CHILLER

2.5.1 General

Chiller shall be designed, constructed tested, and rated in accordance with ANSI/AHRI 560, ANSI/ASHRAE 15 & 34 and shall bear the appropriate Underwriters Laboratories (UL) label. Chiller shall be the single-stage or two-stage hermetic, water-cooled type design, as indicated in contract drawings. Chiller shall be indirectly-fired with steam or hot water, directly-fired with a single or dual fuel burner. For direct-fired units, ratings for cooling capacity, fuel consumption, and COP shall be based on the higher heating value (HHV) or the specific type of fuel utilized. Chiller exterior surfaces shall be factory painted, finished, and insulated as applicable.

2.5.2 Assembly

Unless necessary for delivery purposes, chiller shall be assembled, leak-tested, charged, and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged, and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations.

2.5.3 Operation

Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair shall have lifting eyes or lugs. Chiller shall be provided with insulation on surfaces subject to sweating including the water cooler and water boxes. Chiller shall be provided from the factory with a single point wiring connection for incoming power supply. Magnetic across-the-line motor starters with overload protection shall be provided for each factory supplied pump. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Unit shall be capable of operating automatically and continuously between 10 percent and 100 percent of full load.

2.5.4 Components

Chiller shall include the following as a minimum:

a. Absorber, evaporator, and condenser

b. Generator or first and second stage generators

c. Refrigerant, absorber, and inhibitor solutions

d. Low or low and high temperature heat exchanger(s)

e. Self-contained, hermetically sealed, self lubricating, water cooled, refrigerant and solution pumps. Pumps shall be direct coupled with the motor and shall include isolation valves.

f. Anticrystallization or automatic decrystallization system

g. Factory-installed combustion burner assembly and pre-piped fuel train

h. Cooling/heating switch valve

i. Exhaust gas economizer

j. Automatic purge system, unless otherwise indicated in contract drawings or documents

k. Chiller controls package

l. Interconnecting piping and wiring

m. Grooved mechanical, flanged, or welded connections for water boxes

n. Refrigerant spray nozzles

o. Factory-mounted structural steel base (welded or bolted) or support legs

p. Thermometers and sight glasses to allow visual inspection of unit operation. Mercury shall not be used in thermometers.

2.5.4.1 Absorber, Evaporator, Condenser & Generator

The absorption unit shall be of the shell-and-tube type construction which shall be designed, constructed, tested, and certified in accordance with ASME BPVC SEC VIII D1. The absorber, evaporator, and condenser shall be suitable for not less than 1035 kPa (150 psi) working pressure, unless otherwise indicated. The generator shall have a heating medium of steam or hot water as indicated. The absorption unit may be enclosed in one or two shells with removable water boxes or heads. Condenser tubes shall be seamless copper or copper-nickel. Generator tubes shall be seamless copper-nickel. Absorber and evaporator tubes shall be either seamless copper or seamless copper-nickel. Tube ends shall be rolled into or silver brazed to tube sheets. All copper or copper-nickel tubes shall be seamless and be in accordance with ASTM B395/B395M. For double effect absorption chiller, first stage concentrator tubes shall be titanium and the steam circuit shall comply with ASME BPVC SEC VIII D1. Double effect absorption chillers shall be equipped with capacity modulation to control solution flow entering and leaving the first stage concentrator.

2.5.4.2 Tube Bundles

Provide sufficient clearance between tubes and an adequate number of support sheets, with tubes fitted in the sheets, to prevent chafing of tubes or crevice corrosion due to uneven tube expansion, vibration, or pulsation. Holes in the tube sheets shall not have sharp corners. Each tube shall be removable, in one piece, through holes individually provided for it in tube and support sheets. Water velocities through cooler, condenser and absorber tubes shall range from less than .91 to 3.7 mps (3 to 12 fps). Condenser shall be single or double-tube bundle type.

2.5.4.3 Heads

Provide removable, welded-steel or cast-iron heads for external steam and water connections to permit access to tubes for inspection and cleaning. Design and test water spaces for a working pressure of not less than 1035 kPa (150 psi). Water spaces that are not subject to the ASME Code, due to the size or other limitations, shall be tested at a pressure of not less than 1.5 times the working pressure.

2.5.4.4 Purge System

Provide chiller with an automatically controlled purge system consisting of a motor driven, jet type, or viscosity type, high vacuum pump with separators, pipe connections, and controls. Provide positive protection against return air to unit when evacuator is not in operation.

2.5.4.5 Crystallization

Provide for automatic decrystallization or anti-crystallization, in accordance with manufacturer's standard. If decrystallization is used, provide and arrange for supplemental heating elements if required for automatic operation.

2.5.4.6 Refrigerant and Absorber

Refrigerants shall be distilled or deionized water. Absorbent shall be lithium bromide.

Absorber unit shall be fully charged with water and a nontoxic absorber after installation. Refrigerant and inhibitors shall not generate films that would reduce machine efficiency by coating tubes. The corrosion inhibitor shall not cause the solution to be classified as hazardous waste under the Resource Conservation and Recovery Act.

2.5.5 Combustion Burner Assembly

Chiller shall be provided with a forced draft, flame retention type burner and fuel train assembly. Burner shall be the single or dual fuel type capable of burning natural gas or propane and number 1 fuel oil, number 2 fuel oil, or diesel, as indicated on contract drawings. Burner and fuel train shall be listed by the Underwriters Laboratories (UL). Burner assembly shall be provided with all pressure regulators, switches, controls, ignition system, blower fans, and other devices required for proper and safe operation of the burner. Burner assembly shall be equipped with an external primary-secondary air ratio adjustment that allows adjustment without dismantling the burner. Burner controls shall allow either manual or automatic burner operation. Fuel changeover shall be accomplished by a manual fuel changeover switch or automatically, as indicated.

2.5.6 Controls Package

Chiller shall be provided with a complete factory mounted and prewired electric or microprocessor based control system. Controls package shall be unit-mounted or floor-mounted where indicated which contains as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, power wiring, control wiring, and disconnect switches. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.5.6.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

2.5.6.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. Entering and leaving condenser water temperatures

c. Refrigerant and solution temperatures

d. Generator pressures and temperatures

e. Self diagnostic

f. Operation status

g. Operating hours

h. Number of starts

i. Number of purge cycles over the last 7 days

2.5.6.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. No parameters shall be capable of being changed without first entering a security access code. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature

b. Leaving Condenser Water Temperature

c. Time Clock/Calendar Date

2.5.6.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Refrigerant or solution pump thermal or current overload

b. Low refrigerant temperature

c. Loss of chilled water

d. Loss of condenser water

e. High or low condenser water temperatures

f. Power failure

g. Generator high temperature or pressure

h. Low solution level

i. Burner or related combustion malfunction
j. Burner controls and gas or oil train.

2.5.6.5 Remote Alarm

During the initiation of a safety shutdown, the control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.6.6 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop

b. Remote Chilled Water Reset

c. Remote Condenser Water Reset

2.6 ACCESSORIES

2.6.1 Cleaning Brushes

Furnish chiller with two brushes, having jointed rods, suitable for cleaning evaporator and condenser tubes.

2.6.2 Gaskets

Gaskets shall conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C (700 degrees F) service.

2.6.3 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish.

2.7.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Charging and Testing

Unless fully assembled, tested, evacuated, and charged at factory, components shall be dried and sealed to prevent corrosion of internal surfaces prior to field assembly. Assemble, test, evacuate, and charge units under supervision of manufacturer's representative. Periodic tests shall be readily made on the concentration of the inhibitor and lithium bromide solution with a field test kit furnished by the manufacturer, or as recommended by the manufacturer.

2.8.2 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.8.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with Section 23 65 00 COOLING TOWERS.

2.8.4 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS and 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS into the existing air-conditioning system.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of absorption chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the manufacturer's written installation instructions, including the following:

(1) Water chiller - installation instructions

3.1.1 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting , and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS.

3.1.3 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.4 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for 3 days. The representative shall advise on the following:

Absorption Units:

(1) Testing and evacuation.

(2) Charging the machine with lithium bromide solution and refrigerant water (distilled or demineralized water).

(3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 23 05 93

TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.4 FIELD ACCEPTANCE TESTING

3.4.1 Test Plans

a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

Absorption water chiller - field acceptance test plan

Field acceptance test plans shall be developed by the absorption chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the absorption chiller and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls factory prewired or external controls for the equipment provided under Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS and Section 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS.

c. Prerequisite testing: Absorption chillers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controller shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer shall identify the acceptable limits or tolerance within which each tested performance variable shall acceptably operate.

f. Job specific: Each test plan shall be job specific and shall address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.4.2 Testing

a. Each absorption chiller system shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

Absorption water chiller - field acceptance test report

b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.5 SYSTEM PERFORMANCE TESTS

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5.2 Test Report

The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) For absorption units, the cooling water pressures and temperatures entering and exiting the absorber and condenser. Also the refrigerant solution pressures, concentrations, and temperatures at each measurable point within the system.
(2) Running current, voltage and proper phase sequence for each phase of all motors.
(3) The actual on-site setting of all operating and safety controls.
(4) Chilled water pressure, flow and temperature in and out of the chiller.
(5) The position of the capacity-reduction gear, gas supply control valve, or fuel oil supply valve at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 24 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 450	(2007) Water-Cooled Refrigerant Condensers, Remote Type
AHRI 480	(2007) Refrigerant-Cooled Liquid Coolers, Remote Type
AHRI 550/590 I-P	(2011) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle
AHRI 575	(2008) Method of Measuring Machinery Sound Within an Equipment Space
AHRI 740	(1998) Refrigerant Recovery/Recycling Equipment
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 495	(2005) Performance Rating of Refrigerant Liquid Receivers

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; ERTA 2012; S 2013) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 64	(2011) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013; Errata 1-3 2013; Errata 4-6 2014; Errata 7 2015) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA SM 23	(1991; R 2002) Steam Turbines for Mechanical Drive Service

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 37	(2015) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(2015) National Fuel Gas Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537	(2011) Storage Batteries

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006; Reprint Jul 2011) Standard for Battery Chargers for Charging Engine-Starter Batteries

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Chiller; G

Manufacturer's standard catalog data, at least highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

a. Water Chiller

b. Chiller Components

c. Accessories

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Posted Instructions

Posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Verification of Dimensions

A letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

Manufacturer's Multi-Year Compressor Warranty

Manufacturer's multi-year warranty for compressor(s) in air-cooled water chillers as specified.

Factory Tests

Schedules which identify the date, time, and location for each test. Schedules shall be submitted for both the Chiller Performance Test and the Chiller Sound Test. The Chiller Performance Test schedule shall also allow the witnessing of the test by a Government Representative.

System Performance Tests

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Water Chiller - field acceptance test plan

SD-06 Test Reports

Field Acceptance Testing

Water Chiller - field acceptance test report

Factory Tests

One hard copy & one digital copy (.pdf - text searchable) of the report shall be provided. Reports shall certify the compliance with performance requirements and follow the format of the required testing standard for both the Chiller Performance Tests and the Chiller Sound Tests. Test report shall include certified calibration report of all test instrumentation. Calibration report shall include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report shall be submitted 1 week after completion of the factory test.

System Performance Tests

One hard copy & one digital copy (.pdf - text searchable) of the report shall be provided.

SD-07 Certificates

Refrigeration System; G

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, 1 copy of proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

SD-08 Manufacturer's Instructions

Water Chiller - Installation Instruction; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Provide one hard copy & one digital copy (.pdf - text searchable) of an operation manual, listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Provide one hard copy & one digital copy (.pdf - text searchable) of maintenance manual, listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT REQUIREMENTS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.6 Warranty

In addition to the warranty requirements specification in Division 00, Contract Requirements, the following major components of the chiller shall be covered by a warranty of a duration period of five years: compressor .

1.7 MANUFACTURER'S MULTI-YEAR COMPRESSOR WARRANTY

The Contractor shall provide a 5 year parts and labor (includes refrigerant) manufacturer's warranty on the chiller compressor(s). This warranty shall be directly from the chiller manufacturer to the Government and shall be in addition to the standard one-year warranty of construction. The manufacturer's warranty shall provide for the repair or replacement of the chiller compressor(s) that become inoperative as a result of defects in material or workmanship within 5 years after the date of final acceptance. When the manufacturer determines that a compressor requires replacement, the manufacturer shall furnish new compressor(s) at no additional cost to the Government. Upon notification that a chiller compressor has failed under the terms of the warranty, the manufacturer shall respond in no more than 24 hours. Response shall mean having a manufacturer-qualified technician onsite to evaluate the extent of the needed repairs. The warranty period shall begin on the same date as final acceptance and shall continue for the full product warranty period.

1.7.1 Indexed Notebook

The Contractor shall furnish to the Contracting Officer one hard copy & one digital copy (.pdf - text searchable) of a complete listing of all water chillers covered by a manufacturer's multi-year warranty. The chiller list shall state the duration of the warranty thereof, start date of the warranty, ending date of the warranty, location of the warranted equipment, and the point of contact for fulfillment of the warranty. This information shall be provided for each chiller and the recorded chiller serial numbers shall identify each chiller. Point of contact shall include the name of the service representative along with the day, night, weekend, and holiday phone numbers for a service call. The completed bound and indexed notebook shall be delivered to the Contracting Office prior to final acceptance of the facility.The Contractor shall furnish with each manufacturer's multi-year warranty the name, address, and telephone number (day, night, weekend, and holiday) of the service representative nearest to the location where the equipment is installed. Upon a request for service under the multi-year warranty, the service representative shall honor the warranty during the warranty period, and shall provide the services prescribed by the terms of the warranty.

1.7.2 Equipment Warranty Tags

At the time of installation, each item of manufacturer's multi-year warranted equipment shall be tagged with a durable, oil- and water-resistant tag, suitable for interior and exterior locations, resistant to solvents, abrasion, and fading due to sunlight. The tag shall be attached with copper wire or a permanent, pressure-sensitive, adhesive backing. The tag shall be installed in an easily noticed location attached to the warranted equipment. The tag for this equipment shall be similar to the following in format, and shall contain all of the listed information:

MANUFACTURER'S MULTI-YEAR WARRANTY EQUIPMENT TAG
Equipment/Product Covered: ____________________
Manufacturer:_______Model No.:_____Serial No.:__
Warranty Period: From _________to _____________
Contract No.: _________________________________
Warranty Contact: _____________________________
Name: ____
Address: ______________________________________
Telephone: ____________________________________
STATION PERSONNEL SHALL PERFORM PREVENTIVE
MAINTENANCE AND OPERATIONAL MAINTENANCE

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship.

These products shall have a two year record of satisfactory field service prior to bid opening. The two year record of service shall include applications of equipment and materials under similar circumstances and of similar size.

Products having less than a two year record of satisfactory field service shall be acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record shall not include any manufacturer's prototype or factory testing.

Satisfactory field service shall have been completed by a product that has been, and presently is being sold or offered for sale on the commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, water coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

Nameplates are required on major components if the manufacturer needs to provide specific engineering and manufacturing information pertaining to the particular component. Should replacement of this component be required, nameplate information will insure correct operation of the unit after replacement of this component.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 11.

d. Provide motors in accordance with NEMA MG 11 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

e. Provide inverter duty premium efficiency motors for use with variable frequency drives.

f. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW (10 hp) or less and variable frequency drives for larger motors.

2.4 SELF-CONTAINED WATER CHILLERS, VAPOR COMPRESSION TYPE

Unless necessary for delivery purposes, units shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Parts weighing 23 kg (50 pounds) or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, shall have lifting eyes or lugs. Chiller shall be provided with a single point wiring connection for incoming power supply. Chiller's condenser and water cooler shall be provided with standard water boxes with grooved mechanical, flanged, or welded connections.

2.4.1 Scroll, Reciprocating, or Rotary Screw Type

Chiller shall be rated in accordance with AHRI 550/590 I-P. Chiller shall conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Scroll, reciprocating, or rotary screw compressor

f. Compressor driver, electric motor or gas-engine

g. Compressor driver connection

h. Water cooler (evaporator)

i. Air or water-cooled condenser coil

j. Heat recovery condenser

k. Receiver

l. Tools

2.4.2 Centrifugal or Rotary Screw Type

Chiller shall be constructed and rated in accordance with AHRI 550/590 I-P. Chiller shall conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Centrifugal or rotary screw compressor

f. Compressor driver, electric motor, gas-engine, or steam turbine

g. Compressor driver connection

h. Water cooler (evaporator)

i. Air or water-cooled condenser coil

j. Heat recovery condenser coil

k. Receiver

l. Purge system for chillers which operate below atmospheric pressure

m. Tools

2.5 SPLIT-SYSTEM WATER CHILLER, VAPOR COMPRESSION TYPE

Total chiller system shall be constructed and rated in accordance with ARI 550/590. Individual chiller components shall be constructed and rated in accordance with the applicable ARI standards. Chiller system shall conform to ANSI/ASHRAE 15 & 34. The chiller shall be ASHRAE 90.1 - SI (ASHRAE 90.1 - IP) complaint and 10 CFR Part 433, 434 and 435 efficiency performance standards for federal construction. The manufacturer shall provide certification of compliance. Chiller shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site in strict accordance with manufacturer's recommendations. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's condenser and water cooler shall be provided with standard water boxes with grooved mechanical, flanged, or welded connections. Chillers shall operate at partial load conditions without increased vibration over normal vibration at full load, and shall be capable of continuous operation down to minimum capacity. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Receiver

f. Tools

2.5.1 Compressor-Chiller Unit

As a minimum, the compressor-chiller unit shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Water cooler (evaporator)

2.5.2 Condensing Unit

As a minimum, the condensing unit shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Air or water cooled condenser

2.5.3 Remote Water Cooler (Evaporator)

2.5.3.1 Shell and Tube Type

Cooler shall be constructed and rated in accordance with AHRI 480. Cooler shall be of the shell-and-coil or shell-and-tube type design. Cooler's refrigerant side shall be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side shall be designed and factory pressure tested for not less than 1035 kPa (150 psi), unless otherwise indicated. Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Cooler shall be skid-mounted. Refrigerant circuit shall be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance shall be based on a water velocity not less than .91 mps (3 fps) and not more than 3.7 mps (12 fps) and a fouling factor of 0.00025. Evaporator shall be provided with electric freeze protection type.

2.5.3.2 Brazed Plate Type

Cooler shall be constructed and rated in accordance with AHRI 480. Cooler shall be of the brazed plate design. Cooler's refrigerant side shall be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side shall be designed and factory pressure tested for not less than 1035 kPa (150 psi), unless otherwise indicated. Cooler shell shall be constructed of stainless steel plates brazed together with copper. Refrigerant circuit shall be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance shall be based on a water velocity not less than .91 mps (3 fps) and not more than 3.7 mps (12 fps) and a fouling factor of 0.00025. Evaporator shall be provided with electric freeze protection type.

2.5.4 Remote Air-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit, consisting of coils, fans, and condenser fan motors. Condenser shall be constructed and rated in accordance with ANSI/AHRI 460. Unless the condenser coil is completely protected through inherent design, louvered panel coil guards shall be provided by the manufacturer to prevent physical damage to the coil. Manufacturer shall certify that the condenser and associated equipment are designed for the submitted condensing temperature. For design conditions, if matched combination catalog ratings matching remote condensers to compressors are not available, the Contractor shall furnish a crossplotting of the gross heat rejection of the condenser against the gross heat rejection of the compressor, for the design conditions to show the compatibility of the equipment furnished.

2.5.4.1 Condenser Casing

Condenser casing shall be aluminum not less than 0.040 inch or hot-dip galvanized steel not lighter than 18 gauge. Condensers having horizontal air discharge shall be provided with discharge baffle to direct air upward, constructed of the same material and thickness as the casing.

2.5.4.2 Coil

Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper or aluminum tubes with compatible copper or aluminum fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 5 degrees F subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34. Coil shall be entirely coated with the manufacturer's standard epoxy or vinyl coating.

2.5.4.3 Fans

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced.

2.5.4.4 Condenser Sizing

Size condensers for full capacity at -1.1 degrees C (30 degrees F) temperature difference between entering outside air and condensing refrigerant. Subcooling shall not be considered in determining compressor and condenser capacities. For design conditions, submit a cross-plot of net refrigeration effect of compressor to establish net refrigeration effect and compatibility of equipment furnished.

2.5.4.5 Low Ambient Control

Provide factory mounted head pressure control for operation during low ambient conditions. Head pressure shall be controlled by fan cycling, fan speed control, or condenser refrigerant flooding. Low ambient control shall permit compressor operation below -17.7 degrees C (0 degrees F).

2.5.4.6 High Ambient Unloading

Provide unloading capability to allow operation in high ambient conditions 40.6 to 51.7 degrees C (105 up to 125 degrees F) above design conditions.

2.5.5 Remote Water-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit constructed and rated in accordance with AHRI 450. Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side shall be designed and factory pressure tested for not less than 1035 kPa (150 psi), unless otherwise indicated. Condensers shall be complete with pressure relief valve or rupture disk, water drain connections, refrigerant charging valve, refrigerant valves, liquid-level indicating devices, and stand or saddle. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Condenser performance shall be based on water velocities not less than .91 mps (3 fps) and not more than 3.7 mps (12 fps) and a fouling factor of 0.00025. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 20 percent in excess of the fully charged system for remote water cooled condensers. As a minimum, the condenser shall include the following components as defined in paragraph "Chiller Components".

a. Liquid-level indicating devices.

b. Companion flanges, bolts, and gaskets for flanged water connections.

2.5.6 Remote Evaporatively-Cooled Condenser

Condenser shall be rated and tested in accordance with the requirements of ASHRAE 64. Condenser shall include fans, water pump with suction strainer, electric motor and drive equipment, water eliminators if required, condensing coil, liquid receiver if required, water pan or sump, spray nozzles or water-distribution pan, water strainer, water make-up assembly, bleeder with flow valve of the needle valve type sized for the flow required or a fixed orifice, enclosure with suitable access doors, and air-inlet and outlet openings. No water shall carry over into the unit discharge outlet.

2.5.6.1 Condenser Casing

Enclosure shall be constructed of not lighter than 18 gauge hot-dip galvanized steel or 0.080 inch aluminum, reinforced and braced. Access doors or panels suitably sized and located shall be provided for access to water nozzles or distribution pan, coils, and valves for cleaning, repair, or removal of the item. Access doors or panels shall be gasketed with synthetic rubber, or equivalent gasket material, and locked in place with thumb screws or catches. One-half inch mesh hot-dip galvanized steel or copper air-inlet screens shall be provided on each air inlet.

2.5.6.2 Refrigerant Section

Condenser coil shall be constructed of unfinned copper or steel tubes hot-dip galvanized after fabrication. The receiver shall be welded steel and shall be fitted and tested in accordance with ANSI/AHRI 495. A refrigerant charging valve shall be installed in the liquid line between the receiver cut-off valve and the expansion device. Refrigerant section shall be tested in accordance with ASHRAE 15 for the refrigerant employed in the system.

2.5.6.3 Fans

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced. Fan motor shall be totally enclosed type or open drip-proof and located within an enclosure to be fully protected from the weather.

2.5.6.4 Water Section

Water eliminators shall be constructed of nonferrous metal, of an approved nonmetallic material, or of not lighter than 24 gauge steel, hot-dip galvanized after fabrication. Spray nozzles shall be brass nonclogging type designed to permit easy disassembly, and shall be arranged for easy access. Water pump shall be bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pump suction shall be fully submerged and provided with screened inlet. Water pan or sump shall be constructed of not lighter than 14 gauge steel, hot-dip galvanized after fabrication, or molded acid-resistant glass-fiber-reinforced polyester. Water distribution pan shall be constructed of not lighter than 16 gauge steel, hot-dip galvanized after fabrication. Joints shall be watertight. Water pan or sump shall be provided with drain, overflow, and make-up water connection with stop valve and float valve. A bleed line with a flow valve of the needle type sized for the flow required or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge.

2.6 CHILLER COMPONENTS

2.6.1 Refrigerant and Oil

Refrigerants shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. Refrigerants shall have an Ozone Depletion Potential (ODP) of 0.055 or less. Refrigerants classified by the EPA as Class 2 shall not be allowed with the exception of R-123. The ODP shall be in accordance with the "Montreal Protocol On Substances That Deplete The Ozone Layer," September 1987, as amended through 2000, sponsored by the United Nations Environment Programme.

2.6.2 Structural Base

Chiller and individual chiller components shall be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components shall be isolated from the building structure by means of molded neoprene isolation pads. vibration isolators with published load ratings. Vibration isolators shall have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.

2.6.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit shall be completely piped and factory leak tested. For multicompressor units, not less than 2 independent refrigerant circuits shall be provided. Circuit shall include as a minimum a combination filter and drier, combination sight glass and moisture indicator, liquid-line solenoid valve for reciprocating, an electronic or thermostatic expansion valve with external equalizer, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.6.4 Controls Package

Chiller shall be provided with a complete factory-mounted or remote-mounted, as indicated, prewired electric or microprocessor based operating and safety control system. Controls package shall contain as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, disconnect switches, power wiring, and control wiring. Controls package shall provide operating controls, monitoring capabilities, programmable set-points, safety controls, and EMCS interfaces as defined below.

2.6.4.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer or automated controls to prevent a compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multi-compressor units

d. Load limiting

e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

f. Fan sequencing for air-cooled condenser

2.6.4.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. Self diagnostic

c. Operation status

d. Operating hours

e. Number of starts

f. Compressor status (on or off)

g. Refrigerant discharge and suction pressures

h. Oil pressure

i. Condenser water entering and leaving temperatures

j. Number of purge cycles over the last 7 days

2.6.4.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. No parameters shall be capable of being changed without first entering a security access code. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature

b. Leaving Condenser Water Temperature

c. Time Clock/Calendar Date

2.6.4.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection

b. High condenser refrigerant discharge pressure protection

c. Low evaporator pressure protection

d. Chilled water flow detection

e. High motor winding temperature protection

f. Low oil flow protection if applicable

g. Motor current overload and phase loss protection

2.6.4.5 Safety Controls with Automatic Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection

b. Chilled water flow interlock

c. Phase reversal protection

2.6.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.6.4.7 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop

b. Remote Chilled Water Reset

c. Remote Condenser Water Reset

2.6.5 Compressor(s)

2.6.5.1 Reciprocating Compressor(s)

Rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Compressors shall be capable of operating at partial-load conditions without increased vibration over the normal vibration at full load operation and shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of size 7.45 kW (10 horsepower) and above shall have an oil lubrication system of the reversible, forced-feed type with oil strainer. Shaft seal in open-type units shall be mechanical type. Piston speed for open-type compressors shall not exceed the manufacturer's recommendation or 6 m/s (1200 fpm), whichever is less. Compressors shall include:

a. Vertical, V, W, or radial cylinder design

b. Oil lubrication

c. Integrally cast block of close-grained iron or cast aluminum block with hardened steel cylinder sleeves

d. Oil-level bull's eye

e. Cast cylinder heads

f. Cast-aluminum or forged-steel connecting rods

g. Cast iron or forged-steel crankshaft

h. Main bearings of the sleeve-insert type

i. Crankcase oil heaters controlled as recommended by the manufacturer

j. Suction and discharge refrigerant service valves that are flange connected, wrench operated, with cap

k. A strainer on the suction side of the compressor

l. A hot-gas muffler to reduce vibration and noise from pulsations

2.6.5.2 Scroll Compressor(s)

Compressors shall be of the hermetically sealed design. Compressors shall be mounted on vibration isolators to minimize vibration and noise. Rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Lubrication system shall be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater shall be provided if standard or if available as an option. If provided, the crankcase oil heater shall be controlled as recommended by the manufacturer.

2.6.5.3 Rotary Screw Compressor(s)

Compressors shall operate stably for indefinite time periods at any stage of capacity reduction without hot-gas bypass. Provision shall be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors shall include:

a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Compressor shall allow access to internal compressor components for repairs, inspection, and replacement of parts.

b. Rotors shall be solid steel, possessing sufficient rigidity for proper operation.

c. A maximum rotor operating speed no greater than 3600 RPM. provide cast iron rotor housing

d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors with minimal clearance at rotor tops and rotor ends.

e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

f. Bearing housing shall be conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11.

g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.

h. A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 15 percent.

i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.

j. Crankcase oil heaters controlled as recommended by the manufacturer.

2.6.5.4 Centrifugal Compressor(s)

Centrifugal compressors shall be single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers shall be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft shall be heat-treated alloy steel with sufficient rigidity for proper operation at any required operating speed. Centrifugal compressors shall include:

a. Shaft main bearings that are the rolling element type in accordance with ABMA 9 or ABMA 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Bearings shall be rated for an L(10) life of not less than 200,000 hours.

b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.

c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply. On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment shall allow the compressor to operate only when the required oil pressure is provided to the bearings.

e. Oil sump heaters controlled as recommended by the manufacturer.

f. Temperature-or pressure-actuated prerotation vane or suction damper to provide automatic capacity modulation from 100 percent capacity to 10 percent capacity. If operation to 10 percent capacity cannot be achieved without providing hot-gas bypass, then the Contractor shall indicate in the equipment submittal the load percent at which hot gas bypass is required.

2.6.6 Compressor Driver, Electric Motor

Motors, starters, variable speed drives, wiring, etc. shall be in accordance with paragraph ELECTRICAL WORK. Motor starter shall be unit or remote mounted, as indicated, with starter type, wiring, and accessories coordinated with the chiller manufacturer.

2.6.7 Compressor Driver, Gas-Engine

Gas-engine compressor driver shall operate on natural gas and be in accordance with NFPA 37 and NFPA 54. Engine shall be designed for stationary applications and include all ancillaries necessary for operation. Engine shall be a manufacturer's standard production model and be specifically designed for chiller operation. Engine shall include as a minimum a heavy duty industrial or standard automotive grade block, starting system, lubrication system, coolant system, engine heat exchanger, engine cooling radiator, fuel supply system, electronic ignition, and controls package. Engine shall be naturally aspirated, supercharged, or turbocharged and include appropriate air filters. Engine shall be 2- or 4-stroke-cycle and compression-ignition type. Engine shall be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. Engine shall have a minimum of 2 cylinders. Opposed-piston type engines shall have not less than 4 cylinders. Engine block shall have a coolant drain port.

2.6.7.1 Starting System

Engine starting system shall be the electric type, unless otherwise indicated, and be of sufficient capacity, at the maximum temperature specified, to crank the engine without damage or overheating. Electric starting system shall operate on a 24-volt DC system utilizing a negative circuit ground. A starting battery system shall be provided and shall include the battery, corrosion resistant battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Battery shall be in accordance with SAE J537. Battery charger shall conforming to UL 1236 and be the current-limiting type with overcurrent protection. Pneumatic starting system, if indicated, shall be as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE, for a working pressure of 1.03 MPa (150 psi).

2.6.7.2 Lubrication System

Engine shall be provided with a pressurized oil lubrication system. System shall include a lubrication oil pump that is engine driven. One full-flow filter shall be provided for each pump. Filters shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. System pressure shall be regulated as recommended by the engine manufacturer. A pressure relief valve shall be provided on the crankcase. Crankcase breathers shall be piped to the outside. System shall be readily accessible for servicing such as draining, refilling, and overhauling.

2.6.7.3 Coolant System

Engine shall include an automatic engine jacket water cooling system. Water shall be circulated through the system with an engine-driven circulating pump. System coolant shall use a combination water and ethylene-glycol sufficient for freeze protection at the minimum temperature specified.

2.6.7.4 Engine Heat Exchanger

Engine heat exchanger shall be of the shell-and-tube type construction and be in accordance with ASME BPVC SEC VIII D1. Shell material shall be carbon steel. Tubes shall be seamless copper or copper-nickel. Tubes shall be individually replaceable. Unit's waterside working pressure shall be rated for not less than 1,000 kPa (150 psig) and factory tested at 150 percent of design working pressure. Water connections larger than 75 mm (3 inches) shall be ASME Class 1500 flanged. Unit shall be provided with gasketed removable covers, drains, and vents.

2.6.7.5 Engine Cooling Radiator

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be the pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 48 kPa (7 psi) and shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least 2 tapped holes; one shall be equipped with a drain cock, the rest shall be plugged.

2.6.7.6 Fuel Supply System

Engine fuel supply system shall be factory mounted. System shall include as a minimum a solenoid shut-off valve, a gas pressure regulator, and carburetors (including a throttle body assembly) or fuel injectors.

2.6.7.7 Controls Package

The controls for the gas-engine shall be incorporated into the overall controls package for the water chiller. The engine controls shall be capable of monitoring, displaying, and controlling, as applicable, the following conditions.

a. Coolant-fluid inlet and outlet temperatures

b. Lubricating-oil inlet and outlet temperatures and pressures

c. Engine run-time hours

d. Engine current status mode (on/off)

e. Engine speed

f. Percent engine load

g. Engine jacket temperature

2.6.7.8 Exhaust Piping

Exhaust piping shall be ASTM A53/A53M Schedule 40 seamless black iron, exhaust piping installation shall be per the engine manufacturer's recommendations, except as modified herein. Horizontal sections of exhaust piping shall be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction shall be long radius. Exhaust piping and mufflers shall be insulated in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing, rain cover.

2.6.7.9 Exhaust Muffler

Engine shall be provided with a chamber type exhaust muffler. The muffler shall be of welded steel and designed for outside, inside, vertical, or horizontal mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature 204 degrees C (400 degrees F) resisting paint. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.6.7.10 Exhaust System Connections

Flexible connectors shall be provided at the exhaust piping connection to the engine. An expansion joint shall be provided in the exhaust piping at the muffler connection. Flexible connectors and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for engine exhaust gas at 649 degrees C (1200 degrees F). Flexible connectors and expansion joints shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.6.8 Compressor Driver, Steam Turbine

Steam turbine shall conform to NEMA SM 23 and be suitable for direct connection to the compressor. Turbine shall have a capacity 10 percent greater than the compressor brake horsepower requirement at full-load condition. Steam strainer shall be either internally mounted or installed in connecting piping. Turbine shall include sentinel warning valve, forced-feed lubrication, oil cooler, oil reservoir, oil relief valve, oil piping, oil-pressure gauge, tachometer, and gland-seal piping if a condensing turbine is used. If a non-condensing turbine is used, provision shall be made for drain piping. The turbine shall be suitable for automatic control. An overspeed trip governor shall be provided to shut off the steam supply at 115 percent of design speed. Provision shall be made to stop the turbine upon operation of the compressor safety devices and upon power failure by the use of a solenoid trip on the emergency overspeed governor. Turbine shall be governed by a pneumatically controlled hydraulic governor during automatic operation and with a manual control effective during failure of the air supply. Pneumatic valve shall be actuated by a temperature controller with its sensing element in contact with the chilled water. Turbine shall be designed to operate at the steam pressure and exhaust conditions indicated. If the turbine is a condensing type, a surface-type steam condenser complete with single-stage air ejector, inter- and after-condenser, electric-driven dual condensate pumps, atmospheric relief valve, and expansion joint shall be furnished.

2.6.9 Compressor Driver Connections

Each compressor shall be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives shall be designed for not less than 150 percent of the driving motor capacity. Flexible couplings shall be of the type that does not require lubrication. Each machine driven through speed-increasing gears shall be so designed as to assure self-alignment, interchangeable parts, proper lubrication system, and minimum unbalanced forces. Bearings shall be of the sleeve or roller type. Gear cases shall be oil tight. Shaft extensions shall be provided with seals to retain oil and exclude all dust.

2.6.10 Water Cooler (Evaporator)

Cooler shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa 150 psi. Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on a water velocity not less than 0.91 m/s (3 fps) nor more than 3.7 m/s (12 fps) and a fouling factor of 0.000018 m2(degrees C)/W, 0.000044 m2(degrees C)/W, or 0.000088 m2(degrees C)/W (0.0001 h(ft2)(degrees F)/Btu, 0.00025 h(ft2)(degrees F)/Btu, or 0.0005 h(ft2)(degrees F)/Btu).

2.6.11 Air-Cooled Condenser Coil

Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper or aluminum tubes with compatible copper or aluminum fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C (5 degrees F) subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34. Coil shall be entirely coated with the manufacturer's standard epoxy or vinyl coating.

2.6.12 Water-Cooled Condenser Coil

Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa (150 psi), unless otherwise indicated. Condensers shall be complete with refrigerant relief valve/rupture disc assembly, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 0.91 m/s (3 fps) nor more than 3.7 m/s (12 fps) and a fouling factor of 0.000044 m2(degrees C)/W or 0.000088 m2(degrees C)/W (0.00025 h(ft2)(degrees F)/Btu) or 0.0005 h(ft2)(degrees F)/Btu. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for single packaged systems.

2.6.13 Heat Recovery Condenser Coil

Condenser shall be of the shell-and-coil or shell-and-tube type design and shall not be a part of the standard condenser. Condenser shall be provided and installed by the chiller manufacturer. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa (150 psi). Condenser shall have performance characteristics as indicated on the drawings. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 0.91 m/s (3 fps) nor more than 3.7 m/s (12 fps) and a fouling factor of0.00025.

2.6.14 Receivers

Receiver shall bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and shall meet the requirements of ANSI/ASHRAE 15 & 34. Inner surfaces shall be thoroughly cleaned by sandblasting or other approved means. Each receiver shall have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver shall be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ANSI/ASHRAE 15 & 34, and two bull's eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 75 mm (3 inches) horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.6.15 Chiller Purge System

Chillers which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge system shall automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant. Purge system shall condense, separate, and return all refrigerant back to the chiller. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

2.6.16 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, shall be provided. Tools shall be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.7 ACCESSORIES

2.7.1 Refrigerant Leak Detector

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include a single sampling point installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be compatible with the facility's energy management and control system (EMSS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.7.2 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC VIII D1 and ANSI/ASHRAE 15 & 34. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.7.3 Refrigerant Signs

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 13 mm (0.5 inches) in height.

2.7.3.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.7.3.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg (110 lb)of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow , the ventilation system, and the refrigerant compressor(s).

b. Pressure limiting device(s).

2.7.4 Refrigerant Recovery/Recycle System

A manually initiated refrigerant recovery/recycle system shall be provided, consisting of a motor-driven, air- or water-cooled, reciprocating condensing unit and a receiver of sufficient capacity to store the entire refrigerant charge of the largest water-chilling system. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C (68 degrees F) the receiver shall be sized so that it is no more than 80 percent full at 32 degrees C (90 degrees F). For refrigerants with atmospheric pressure boiling temperature above 20 degrees C (68 degrees F), the receiver shall be sized so that it is no more than 90 percent full at 32 degrees C (90 degrees F). The recovery/recycle system condensing unit shall be assembled as a complete unit and meet the requirements of ANSI/ASHRAE 15 & 34. The system components shall be portable and shall include all valves, connections, and controls required for operation. Receiver and relief devices shall conform to the requirements of ASME BPVC SEC VIII D1. The recovery/recycle system shall be tested and listed to conform to AHRI 740 for refrigerant recovery/recycle systems by a recognized national testing laboratory. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C (68 degrees F), the recovery/recycle unit shall have an AHRI 740 vapor refrigerant recovery rate of no less than 8.5 kg/minute (17.0 lb/minute). For refrigerants with atmospheric pressure boiling temperature above 20 degrees C (68 degrees F), the recovery/recycle unit shall have an AHRI 740 vapor refrigerant recovery rate of no less than 1.0 kg/minute (2.2 lb/minute).

2.7.5 Automatic Tube Brush Cleaning System

2.7.5.1 Brush and Basket Sets

One brush and basket set (one brush and two baskets) shall be furnished for each condenser tube. Brushes shall be made of nylon bristles, with titanium wire. Baskets shall be polypropylene.

2.7.5.2 Flow-Diverter Valve

Each system shall be equipped with one flow-diverter valve specifically designed for the automatic tube brush cleaning system and have parallel flow connections. The flow-diverter valve shall be designed for a working pressure of 1,000 kPa (150 psig), unless otherwise indicated. End connections shall be flanged. Each valve shall be provided with an electrically operated air solenoid valve and position indicator.

2.7.5.3 Control Panel

The control panel shall provide signals to the diverter valve at a preset time interval to reverse water flow to drive the tube brushes down the tubes and then signal the valve to reverse the water flow to drive the brushes back down the tubes to their original position. The controller shall have the following features as a minimum:

a. Timer to initiate the on-load cleaning cycle.

b. Manual override of preset cleaning cycle.

c. Power-on indicator.

d. Diverter-position indicator.

e. Cleaning-cycle-time adjustment

f. Flow-switch bypass.

2.7.6 Gaskets

Gaskets shall conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C (700 degrees F) service.

2.7.7 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.8 FABRICATION

2.8.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.8.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.9 FACTORY TESTS

2.9.1 Chiller Performance Test

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, and IPLV or NPLV in accordance with AHRI 550/590 I-P, except as indicated. The Contractor and chiller manufacturer shall provide to the Government a certified chiller factory test report in accordance with AHRI 550/590 I-P to confirm that the chiller performs as specified. Tests shall be conducted in an ARI certified test facility in conformance with AHRI 550/590 I-P procedures and tolerances, except as indicated. At a minimum, chiller capacity shall be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation shall be in strict accordance with AHRI 550/590 I-P. Stable operation at minimum load of 10 percent of total capacity shall be demonstrated during the factory test.

2.9.1.1 Temperature Adjustments

Temperature adjustments shall adhere to AHRI 550/590 I-P to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments shall be verified prior to testing by the manufacturer. There shall be no exceptions to conducting the test with clean tubes with the temperature adjustments per AHRI 550/590 I-P. The manufacturer shall clean the tubes, if necessary, prior to testing to obtain a test fouling factor of 0.0000.

2.9.1.2 Test Instrumentation

The factory test instrumentation shall be per AHRI 550/590 I-P and the calibration shall be traceable to the National Institute of Standards and Technology.

2.9.1.3 Test Report

A certified test report of all data shall be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation shall be provided.

2.9.1.4 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer shall be allowed to make necessary revisions to his equipment and retest as required.

2.9.2 Chiller Sound Test

Chillers shall be sound tested at the factory prior to shipment to confirm the sound pressure level specified herein. Tests and data shall be conducted and measured in strict accordance with AHRI 575 at the full load system operating conditions. The chiller sound pressure level, in decibels (dB), with a reference pressure of 20 micropascals, shall not exceed 90 dB, A weighted. Ratings shall be in accordance with AHRI 575. No reduction of entering condenser water temperature or raising of leaving chilled water temperature shall be allowed. A minimum of 75 percent of the sound data points shall be taken along the length of the machine, and established as the minimum percentage of total possible points used to determine sound levels. In the event that the chiller does not meet the dBA sound pressure level, the manufacturer shall, at his expense, provide sufficient attenuation to the machine to meet the specified value. This attenuation shall be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller. The attenuation material, adhesives, coatings, and other accessories shall have surface burning characteristics as determined by ASTM E84.

2.10 SUPPLEMENTAL COMPONENTS/SERVICES

2.10.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.10.2 Refrigerant Piping

Refrigerant piping for split-system water chillers shall be provided and installed in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.10.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with Section 23 65 00 COOLING TOWERS.

2.10.4 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or into the existing air-conditioning system, as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of water chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the manufacturer's written installation instructions, including the following:

1. Water chiller - installation instructions

3.1.1 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.2 Refrigeration System

3.1.2.1 Equipment

Refrigeration equipment and the installation thereof shall conform to ANSI/ASHRAE 15 & 34. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, water coolers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm (6 inch) concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Recommended transmissibility in percentages is: 10 percent for equipment mounted in very critical areas, 10 to 20 percent for critical areas, and 20 to 40 percent for noncritical areas. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.2.2 Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system shall be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor shall provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system shall be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points shall be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant shall be pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.2.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the performance testing period, and upon the satisfactory completion of the tests, the oil shall be drained and replaced with the second charge.

3.1.3 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.1.4 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.5 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for 8 hours. The representative shall advise on the following:

a. Hermetic machines:

   (1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 microns.

   (2) Charging the machine with refrigerant.

   (3) Starting the machine.

b. Open Machines:

   (1) Erection, alignment, testing, and dehydrating.

   (2) Charging the machine with refrigerant.

   (3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers shall be cleaned in accordance with the chiller manufacturer's instructions. This work covers two coil cleanings. The condenser coils shall be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner shall not have any detrimental effect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing shall be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.4 FIELD ACCEPTANCE TESTING

3.4.1 Test Plans

a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

(1) Water chiller - field acceptance test plan

Field acceptance test plans shall be developed by the absorption chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the absorption chiller and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls factory prewired or external controls for the equipment provided under Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

c. Prerequisite testing: Absorption chillers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controller shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer shall identify the acceptable limits or tolerance within which each tested performance variable shall acceptably operate.

f. Job specific: Each test plan shall be job specific and shall address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.4.2 Testing

a. Each water chiller system shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

1. Water chiller - field acceptance test report

b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.5 SYSTEM PERFORMANCE TESTS

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5.2 Test Report

The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

   (1) The refrigerant used in the system.
   (2) Condensing temperature and pressure.
   (3) Suction temperature and pressure.
   (4) Running current, voltage and proper phase sequence for each phase of all motors.
   (5) The actual on-site setting of all operating and safety controls.
   (6) Chilled water pressure, flow and temperature in and out of the chiller.
   (7) The position of the capacity-reduction gear, gas supply control valve, and fuel oil supply valve at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 23 64 26

CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4	(1999; Addenda A 2000, Addenda B 2001; R 2014) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2009) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1017	(2009) Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2011) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded

ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.2.6M	(2012) Metric Fasteners for Use in Structural Applications
ASME B31.9	(2014) Building Services Piping
ASME B36.10M	(2004; R 2010) Standard for Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2014) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

ASTM A194/A194M	(2014) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A197/A197M	(2000; R 2011) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2003; E 2009; R 2009) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B42	(2010) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B813	(2010) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper

	and Copper Alloy Tube
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1384	(2005; R 2012) Corrosion Test for Engine Coolants in Glassware
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D596	(2001; R 2011) Reporting Results of Analysis of Water
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1007	(1986; R 2014) Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F104	(2011) Standard Classification System for Nonmetallic Gasket Materials
ASTM F1120	(1987; R 2010) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASTM F1199	(1988; R 2010) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2011) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2008) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2011) Butterfly Valves
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2011; Errata 2013) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2014) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(2007) Taper Pipe Threads
KS B 1503	(2007) Steel Welding Pipe Flanges
KS B 1531	(2011) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1536	(2009) Bellows Type Expansion Pipe Joints
KS B 1541	(2009) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel socket-welding pipe Fittings

KS B 1543	(2009) Steel plate butt-welding pipe fittings
KS B 1544	(2012) Copper alloy solder-Joint fittings
KS B 1545	(2006) Copper and Copper Alloy Fittings for Flared Copper Tubes
KS B 2301	(2009) Bronze Gate, Globe, Angle and Check Valves
KS B 2333	(2012) Butterfly Valves for Water Works
KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes

1.2 SYSTEM DESCRIPTION

Provide the water systems having the minimum service (design) temperature-pressure rating indicated. Provision of the piping systems, including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the required and advisory provisions of ASME B31.9 except as modified or supplemented by this specification section or design drawings. This specification section covers the water systems piping which is located within, on, and adjacent to building(s) within the building(s) 1.66 meter (5 foot) line.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Grooved Mechanical Connections For Steel; G

Grooved Mechanical Connections For Copper; G

Calibrated Balancing Valves; G

Automatic Flow Control Valves; G

Pump Discharge Valve

Water Temperature Mixing Valve; G

Water Temperature Regulating Valves; G

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints; G

Pumps; G

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

Water Treatment Systems; G

Proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph "Water Analysis", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

SD-06 Test Reports

Piping welds NDE report

Pressure tests reports; G

One hard copy & one digital copy (.pdf - text searchable) of report shall be provided. Hard copy shall be in bound 216 by 279 mm (8-1/2 by 11 inches) booklet. In the reports, document all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results.

Condenser Water Quality Test Reports; G

One hard copy & one digital copy (.pdf - text searchable) of test reports, each month for a period of one year after project completion. Hard copy shall be in bound 216 by 279 mm (8-1/2 by 11 inch booklet. In the reports, identify the chemical composition of the condenser water. Also include the comparison of the manufacturer's recommended operating conditions for the cooling tower and condenser in relation to the condition of the condenser water. Document in the report any required corrective action taken.

One-Year Inspection Report For Cooling Water; G

At the completion of one year of service, provide one hard copy & one digital copy (.pdf - text searchable) of inspection report. Hard copy shall be in bound 216 by 279 mm (8-1/2 by 11 inch booklet. In the report, identify the condition of each cooling tower and condenser. Include a comparison of the condition of the cooling tower and condenser with the manufacturer's recommended operating conditions. Identify all actions taken by the Contractor and manufacturer to correct deficiencies during the first year of service.

SD-07 Certificates

Employer's Record Documents (For Welding)

Welding Procedures and Qualifications

Certificates shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Piping for Steam and Condensate
Piping for High-Pressure Compressed-Air Systems
Fittings
Unions
Flanges
Gaskets
Bolting

SD-08 Manufacturer's Instructions

Lesson plan for the Instruction Course; G

SD-10 Operation and Maintenance Data

Requirements for data packages are specified Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as supplemented and modified by this specification section.

Submit spare parts data for each different item of equipment specified, with operation and maintenance data packages. Include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Submit a list of qualified permanent service organizations with operation and maintenance data packages. Include service organization addresses and service area or expertise. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

Water Treatment Systems; G

One hard copy & one digital copy (.pdf - text searchable) of operation manual. Hard copy shall be in bound 216 by 279 mm (8-1/2 by 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown. Include testing procedures used in determining water quality.

One hard copy & one digital copy (.pdf - text searchable) of maintenance manual. Hard copy shall be in bound 216 by 279 mm (8-1/2 by 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide.

Calibrated Balancing Valves, Data Package 3; G

Automatic Flow Control Valves, Data Package 3; G

Pump Discharge Valve, Data Package 2; G

Water Temperature Mixing Valve, Data Package 3; G

Water Temperature Regulating Valves, Data Package 3; G

Water Pressure Reducing Valve, Data Package 3; G

Pressure Relief Valve, Data Package 2; G

Combination Pressure and Temperature Relief Valves, Data Package 2; G

Expansion Joints, Data Package 2; G

Pumps, Data Package 3; G

Combination Strainer and Pump Suction Diffuser, Data Package 2; G

Expansion Tanks, Data Package 2; G

Air Separator Tanks, Data Package 2; G

1.4 MODIFICATIONS TO REFERENCES

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.5 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter. Any porous materials found to be contaminated with mold or mildew will be replaced at the Contractor's expense. Non-porous materials found to be contaminated with mold or mildew will be disinfected and cleaned prior to installation.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.7.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.7.3 Accessibility

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

The two year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components shall be environmentally suitable for the indicated locations.

The equipment items shall be supported by service organizations. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 STEEL PIPING

Water piping shall be steel pipe or copper tubing. Provide steel piping with a ANSI/ASME Class 125 service rating, which for 66 degrees C the pressure rating is 1207 kPa (150 degrees F, the pressure rating is 175 psig).

2.2.1 Pipe

Steel pipe, conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.2.2 Fittings and End Connections (Joints)

Piping and fittings 25 mm (1 inch) and smaller shall have threaded connections. Piping and fittings larger than 25 mm (1 inch) and smaller than 80 mm (3 inches) shall have either threaded, grooved, or welded connections. Piping and fittings 80 mm (3 inches) and larger shall have grooved, welded, or flanged connections. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.2.2.1 Threaded Connections

Use threaded valves and pipe connections conforming to ASME B1.20.1 or KS B 0222. Used threaded fitting conforming to ASME B16.3 or KS B 1531. Use threaded unions conforming to ASME B16.39 or KS B 1531. Use threaded pipe nipples conforming to ASTM A733.

2.2.2.2 Flanged Connections

Flanges shall conform to ASME B16.1, Class 150. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.59 mm (1/16 inch) thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadeine rubber (SBR) or nitrile butadeine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.1.

2.2.2.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9. Butt-welded fittings shall conform to ASME B16.9, KS B 1541, or KS B 1543. Socket-welded fittings shall conform to ASME B16.11 or KS B 1542. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.2.2.4 Grooved Mechanical Connections For Steel

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 110 degrees C (230 degrees F). Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Use fitting and coupling houses of malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12; or steel conforming ASTM A106/A106M, Grade B or ASTM A53/A53M. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and conforming to ASTM D2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 110 degrees C (230 degrees F) or Grade No. M3BA610A15B44Z for circulating medium up to 93 degrees C (200 degrees F). Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183. Pipe connections and fittings shall be the product of the same manufacturer. Provide joint installation be in compliance with joint manufacturer's written instructions.

2.2.2.5 Dielectric Waterways and Flanges

Provide dielectric waterways with a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Provide dielectric waterways constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Provide dielectric flanges with the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.3 PIPING FOR STEAM AND CONDENSATE

Steam and condensate piping for 1034-, 2413-, 13790-, 41369- kilopascal (150-, 350-, 2,000-, and 6,000-pound per square inch (psi)) service shall be black carbon steel (BCS). Steam and condensate piping includes fittings, unions, flanges, gaskets, and bolting.

2.3.1 Type BCS-150 (1034 kilopascal (150-psi) Service)

Pipe or tube (DN6 through DN25)(1/8 inch through 1 inches): Schedule 40 for steam, Schedule 80 for condensate, seamless black carbon steel, conforming to ASTM A106/A106M, Grade B and ASME B36.10M

Fittings (DN6 through DN50)(1/8 inch through 2 inches): 2068 kilopascal (300-psi) working steam pressure (wsp) banded malleable iron, screwed end, conforming to ASTM A197/A197M and ASME B16.3

Fittings (DN6 through DN50)(1/8 inch through 2 inches): 15- or 20-megapascal (2,000-or 3,000-psi) water, oil, or gas (wog) forged carbon steel, socket weld or screwed end, conforming to ASTM A105/A105M and ASME B16.11 or KS B 1542

Fittings (DN65 through DN250)(2-1/2 through 10 inches): Wall thickness to match pipe, long radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9 or KS B 1541 or KS B 1543

Unions (DN6 through DN50)(1/8 inch through 2 inches): 1724 kilopascal

(250-psi) wsp, malleable iron, screwed end, ground joint, with brass or bronze seat insert, conforming to ASME B16.39

Unions (DN6 through DN50)(1/8 inch through 2 inches): 15- or 20- megapascal (2,000 or 3,000-psi) wog, forged carbon steel; socket weld through 50 millimeter (2-inch), screwed end through 25 millimeter (1-inch), conforming to ASTM A105/A105M and ASME B16.11 or KS B 1542, with ground joint and stainless-steel seat insert

Flanges (DN65 through DN250)(2-1/2 through 10 inches: 1034-kilopascal (150-pound), forged carbon steel, welding neck, with raised face or flat face and concentric finish, conforming to ASTM A105/A105M and ASME B16.5 or KS B 1503

Flange Gaskets: Compressed non-asbestos sheet conforming to ASTM F104, Type 1, P1161A, coated on both sides with graphite or similar lubricant, containing not less than 75-percent non-asbestos fiber materials

Bolting: Bolting and flange bolting shall be hexhead and shall conform to ASTM A325M (ASTM A325). Heavy hex-nuts shall conform to ASME B18.2.6M (ASME B18.2.2). Square-head bolts and nuts are not acceptable.

2.3.2 Type BCS-350 (2413 kilopascal (350-psi)Service)

Pipe or tube (DN6 through DN25)(1/8 inch through 1 inches): Schedule 40 for steam, Schedule 80 for condensate; seamless black carbon steel, conforming to ASTM A106/A106M, Grade B and ASME B36.10M

Fittings (DN6 through DN50) (1/8 inch through 2 inches): 15- or 20- megapascal (2,000-or 3,000-psi)wog to match pipe wall, forged carbon steel, socket weld or screwed end, conforming to ASTM A105/A105M and ASME B16.11 or KS B 1542

Fittings (DN6 through DN25) (1/8 inch through 10 inches): Schedule 40, long-radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9 or KS B 1541 or KS B 1543

Unions (DN6 through DN50) (1/8 inch through 2 inches): 15- or 20- megapascal (2,000-or 3,000-psi)wog to match pipe wall, forged carbon steel, socket weld through 50 millimeter (2-inch), screwed end through 25 millimeter (1-inch), conforming to ASTM A105/A105M and ASME B16.11 or KS B 1542, with ground joint and stainless-steel seat insert

Flanges (DN65 through DN250) (2-1/2 through 10 inches): 2068 kilopascal (300-pound), forged carbon steel, weld neck, with raised face and concentric serrated finish, conforming to ASTM A181/A181M, Class 70, and ASME B16.5 or KS B 1503

Gaskets: Spiral-wound, non-asbestos-fiber-filled, carbon steel, with centering provisions, conforming to ASME B16.5 or KS B 1503, Group 1

Bolting: Heavy hex-head, carbon-steel bolts or bolt studs and semifinished heavy hexnuts, conforming to ASTM A325M (ASTM A325).

Square-head bolts are not acceptable.

2.4 PIPING FOR HIGH-PRESSURE COMPRESSED-AIR SYSTEMS

High-pressure compressed-air condensate piping includes fittings, unions, flanges, gaskets, and bolting.

2.4.1 Type BCS-2,000 (15 megapascal (2,000-psi) Service)

Pipe or tube (DN6 through DN80) (1/8 inch through 3 inches): Schedule 40, seamless black carbon steel, conforming to ASTM A106/A106M, Grade B, or ASTM A53/A53M, Grade B, Type S, and ASME B36.10M

Fittings (DN6 through DN40) (1/8 inch through 1-1/2 inches): 15 megapascal (2,000-psi) wog, forged carbon steel, socket weld, conforming to ASTM A105/A105M and ASME B16.11 or KS B 1542

Fittings (DN50 through DN80) (2 through 3 inches): Schedule 40, long radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9 or KS B 1541 or KS B 1543

Flanges (DN25 through DN80) (1 inch through 3 inches: 6200 kilopascal (900-pound), forged carbon steel, welding neck, with raised face and concentric serrated finish, conforming to ASTM A105/A105M or ASTM A181/A181M, Class 60, and ASME B16.5 or KS B 1503

Gaskets: Spiral wound, non-asbestos-fiber-filled, carbon steel, with centering provisions, conforming to ASME B16.5 or KS B 1503, Group 1

Bolting: Alloy-steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hex-nuts, conforming to ASTM A194/A194M, Grade 2H

2.4.2 Type BCS-6,000 (41368-kilopascal 6,000-psiService)

Pipe or tube (DN15 through DN80) (1/2 inch through 3 inches): XXS, seamless, black carbon steel, conforming to ASTM A106/A106M, Grade B, or ASTM A53/A53M, Grade B, Type S and ASME B36.10M

Fittings (DN15 through DN40) (1/2 inch through 1-1/2 inches) : 41.3 megapascal (6,000-psi) wog, forged carbon steel, socket weld, conforming to ASTM A105/A105M and ASME B16.11 or KS B 1542

Fittings (DN50 through DN80) (2 through 3 inches): XXS, long-radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, ASME B16.9 or KS B 1541 or KS B 1543, and ASME B36.10M

Flanges (DN50 through DN80) (2 through 3 inches): 17.2 megapascal (2,500-pound), forged carbon steel, welding neck with raised face and concentric serrated finish, conforming to ASTM A105/A105M and ASME B16.5 or KS B 1503

Gaskets: Spiral-wound, non-asbestos-filled, carbon steel, with centering provisions, conforming to ASME B16.5 or KS B 1503, Group 1

Bolting: Alloy steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hex-nuts, conforming to ASTM A194/A194M, Grade 2H

2.5 COPPER TUBING

Provide copper tubing and fittings with a ANSI/ASME Class 125 service rating, which for 66 degrees C, the pressure rating is 1207 kPa (150 degrees F., the pressure rating is 175 psig).

2.5.1 Tube

Use copper tube conforming to ASTM B88M (ASTM B88), Type L or M or KS D 5301 for aboveground tubing, and Type K for buried tubing.

2.5.2 Fittings and End Connections (Solder and Flared Joints)

Wrought copper and bronze solder joint pressure fittings, including unions and flanges, shall conform to ASME B16.22 or KS B 1544 andASTM B75/B75M. Provide adapters as required. Cast copper alloy solder-joint pressure fittings , including unions and flanges, shall conform to ASME B16.18 or KS B 1544. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 or KS B 1545 and ASTM B62. ASTM B42 copper pipe nipples with threaded end connections shall conform to ASTM B42.

Copper tubing of sizes larger than 100 mm (4 inches) shall have brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

Extracted brazed tee joints may be used if produced with an acceptable tool and installed in accordance with tool manufacturer's written procedures.

2.5.3 Grooved Mechanical Connections For Copper

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 110 degrees C (230 degrees F). Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Provide gaskets for use in grooved joints shall constructed of molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 110 degrees C (230 degrees F). Provide grooved joints in conformance with AWWA C606.

2.5.4 Solder

Provide solder in conformance with ASTM B32, grade Sb5, tin-antimony alloy. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

2.5.5 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.6 VALVES

Provide valves with a ANSI/ASME Class 125 service rating, which for 66 degrees C, the pressure rating is 1207 kPa (150 degrees F, the pressure rating is 175 psig).

Valves in sizes larger than 25 mm (1 inch) and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be furnished by the same manufacturer as the grooved pipe joint and fitting system.

2.6.1 Gate Valve

Gate valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 Class 125 or KS B 2301 and shall be bronze with wedge disc, rising stem and threaded, soldered, or flanged ends. Gate valves 80 mm (3 inches) and larger shall conform to MSS SP-70, Class 125, cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.6.2 Globe and Angle Valve

Globe and angle valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80, Class 125 or KS B 2301. Globe and angle valves 80 mm (3 inches) and larger shall conform to MSS SP-85, Class 125.

2.6.3 Check Valve

Check valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 or KS B 2301. Check valves 80 mm (3 inches) and larger shall conform to MSS SP-71, Class 125.

2.6.4 Butterfly Valve

Butterfly valves shall conform to MSS SP-67, Type 1 or KS B 2333 and shall be either the wafer or lug type. Valves smaller than 200 mm (8 inches) shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators.

2.6.5 Plug Valve

Plug valves 50 mm (2 inches) and larger shall conform to MSS SP-78, have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves 50 mm (2 inches) and smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valve shall be lubricated, non-lubricated, or tetrafluoroethylene resin-coated type. Valve shall be resilient, double seated, trunnion mounted with tapered lift plug capable of 2-way shutoff. Valve shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valve shall a weatherproof operators with mechanical position indicators. Valves 200 mm (8 inches) or larger shall be provided with manual gear operators with position indicators.

2.6.6 Ball Valve

Full port design. Ball valves 15 mm (1/2 inch) and larger shall conform to MSS SP-72 or MSS SP-110 and shall be cast iron or bronze with threaded, soldered, or flanged ends. Valves 200 mm (8 inches) or larger shall be provided with manual gear operators with position indicators. Ball valves may be provided in lieu of gate valves.

2.6.7 Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

2.6.8 Calibrated Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts. Provide valve calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Valve shall have an integral pointer which registers the degree of valve opening. Valve shall function as a service valve when in fully closed position. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation.

Provide valve bodies with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable differential pressure meter connections to verify the pressure differential. Provide metal tag on each valve showing the liters per second (gallons per minute) flow for each differential pressure reading. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.6.9 Automatic Flow Control Valves

Valve shall automatically maintain the constant flow indicated on the design drawings. Valve shall modulate by sensing the pressure differential across the valve body. Valve shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Provide valve that controls the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves.

Provide valves that are electric or pneumatic type as indicated. Valve shall be capable of positive shutoff against the system pump head, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings and differential meter, suitable for the operating pressure specified. Provide the meter complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.6.10 Pump Discharge Valve

Valve shall perform the functions of a nonslam check valve, a manual balancing valve, and a shutoff. Valve shall be of cast iron or ductile iron construction with bronze and/or stainless steel accessories. Provide an integral pointer on the valve which registers the degree of valve opening. Flow through the valve shall be manually adjustable from bubble tight shutoff to full flow. Valves smaller than 50 mm (2 inches) shall have NPT connections. Valves 50 mm (2 inches) and larger shall have flanged or grooved end connections. Valve design shall allow the back seat for the stem to be replaced in the field under full line pressure.

2.6.11 Water Temperature Mixing Valve

Valve, ASSE 1017 for water service.

2.6.12 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.6.13 Water Pressure Reducing Valve

Valve, ASSE 1003 for water service, copper alloy body, automatic re-seating, with test lever.

2.6.14 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve, ANSI Z21.22/CSA 4.4 and shall have cast iron bodies with corrosion resistant internal working parts. The discharge pipe from the relief valve shall be the size of the valve outlet unless otherwise indicated.

2.6.15 Combination Pressure and Temperature Relief Valves

ANSI Z21.22/CSA 4.4, copper alloy body, automatic re-seating, test lever, and discharge capacity based on AGA temperature steam rating.

2.6.16 Float Valve

Valve bodies 80 mm(3 inches) nominal pipe size and smaller shall be bronze. Valve bodies larger than 80 mm(3 inches) shall be cast iron or bronze. Steel parts shall be corrosion resistant. Where float rods are extended for tank applications, extension shall be properly supported and guided to avoid bending of float rod or stressing of valve pilot linkage. Where float rods are extended for tank applications, extension shall be properly supported and guided to avoid bending of float rod or stressing of valve pilot linkage.

2.6.17 Drain Valves

Valves, MSS SP-80 gate valves. Valve shall be manually-operated, 20 mm (3/4 inch) pipe size and above with a threaded end connection. Provide valve with a water hose nipple adapter. Freeze-proof type valves shall be provided in installations exposed to freezing temperatures.

2.6.18 Air Venting Valves

Automatic type ball-float type air venting valves with brass/bronze or brass bodies, 300 series corrosion-resistant steel float, linkage and removable seat, unless otherwise indicated. Air venting valves on water coils shall have not less than 3 mm (1/8 inch) threaded end connections. Air venting valves on water mains shall have not less than 20 mm (3/4 inch) threaded end connections. Air venting valves on all other applications shall have not less than 15 mm (1/2 inch) threaded end connections.

2.6.19 Vacuum Relief Valves

ANSI Z21.22/CSA 4.4

2.7 PIPING ACCESSORIES

2.7.1 Strainer

Strainer, ASTM F1199, except as modified and supplemented in this specification. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. The bodies shall have arrows clearly cast on the sides indicating the direction of flow.

Provide strainer with removable cover and sediment screen. The screen shall be made of minimum 0.8 mm (22 gauge) brass sheet, monel, or corrosion-resistant steel, with small perforations numbering not less than 60 per square centimeter (400 per square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.7.2 Cyclonic Separator

Metal- bodied, with removal capability of removing solids 45 microns/325 mesh in size and heavier than 1.20 specific gravity, maximum pressure drop of 35 kPad (5 psid), with cleanout connection.

2.7.3 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer shall be in accordance with ASTM F1199, except as modified and supplemented by this specification. Unit body shall have arrows clearly cast on the sides indicating the direction of flow.

Strainer screen shall be made of minimum 0.8 mm (22 gauge) brass sheet, monel, or corrosion-resistant steel, with small perforations numbering not less than 60 per square centimeter (400 per square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations. Provide an auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal.

Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.7.4 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid. Equip flanged assemblies with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Provide covers to protect the bellows where indicated.

2.7.5 Pressure and Vacuum Gauges

Gauges, ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Provide gauges with 115 mm (4.5 inch) dial, brass or aluminum case, bronze tube, and siphon. Gauge shall have a minimum of with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.7.6 Temperature Gauges

Temperature gauges, shall be the industrial duty type and be provided for the required temperature range. Provide gauges with fixed thread connection, dial face gasketed within the case; and an accuracy within 2 percent of scale range. Gauges shall have Celsius scale in 1 degree (Fahrenheit scale in 2 degree) graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1.5 m (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1.5 to 2.1 m (5 to 7 feet) above the finished floor or in locations indicated. Remote element type temperature gauges shall be provided in thermal wells located 2.1 m (7 feet) above the finished floor or in locations indicated.

2.7.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.7.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment.

2.7.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm, (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.7.6.4 Thermal Well

Thermal well shall be identical size, 15 or 20 mm (1/2 or 3/4 inch) NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 15 mm (1/2 inch) NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm (1 inch).

2.7.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports: to MSS SP-58 and MSS SP-69.

2.7.8 Escutcheons

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Secure plates in place by internal spring tension or set screws. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.7.9 Expansion Joints

2.7.9.1 Slip-Tube Type

Slip-tube expansion joints, ASTM F1007, Class I or II. Joints shall be provided with internally-externally alignment guides, injected semi-plastic packing, and service outlets. End connections shall be flanged or beveled for welding as indicated. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer.

2.7.9.2 Flexible Ball Type

Flexible ball expansion joints shall be capable of 360 degrees rotation plus 15 degrees angular flex movement. Joints shall be constructed of carbon steel with the exterior spherical surface of carbon steel balls plated with a minimum 0.12 mm (5 mils) of hard chrome in accordance with EJMA Stds. Joint end connections shall be threaded for piping 50 mm (2 inches) or smaller. Joint end connections larger than 50 mm (2 inches) shall be grooved, flanged, or beveled for welding. Provide joint with pressure-molded composition gaskets suitable for continuous operation at twice design temperature.

2.7.9.3 Bellows Type

Bellows expansion type joints, ASTM F1120 with Type 304 stainless steel corrugated bellows or KS B 1536, reinforced with equalizing rings, internal sleeves, and external protective covers. Joint end connections shall be grooved, flanged, or beveled for welding. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint.

2.8 PUMPS

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to HI 1.1-1.2. Pumps shall be selected at or within 5 percent of peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall conform to NEMA MG 1, be totally enclosed, unless otherwise indicated, and have sufficient wattage (horsepower) for the service required. Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 180 kPa (60 feet of water), the pump speed shall not exceed 1,750 rpm. Pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.8.1 Construction

Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 862 kPa (125 psig). Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Provide threaded suction and discharge pressure gage tapping with square-head plugs.

Impeller shall be statically and dynamically balanced. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water.

Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings. Pump shall be provided with steel shaft coupling guard. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface. Close-coupled pump shall be provided with integrally cast or fabricated steel feet with bolt holes for securing feet to supporting surface. Close- coupled pumps shall be provided with drip pockets and tapped openings. Pump shall be accessible for servicing without disturbing piping connections. Shaft seals shall be mechanical-seals or stuffing-box type.

2.8.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone particle separator in line.

2.8.3 Stuffing-Box Type Seals

Stuffing box shall include minimum 4 rows of square, impregnated TFE (Teflon) or graphite cord packing and a bronze split-lantern ring. Packing gland shall be bronze interlocking split type.

2.9 EXPANSION TANKS

Tank shall be welded steel, constructed for, and tested to pressure-temperature rating of 862 kPa at 66 degrees C (125 psi at 150 degrees F). Provide tanks precharged to the minimum operating pressure. Tank shall have a replaceable polypropylene or butyl lined diaphragm which keeps the air charge separated from the water; shall be the captive air type.

Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.10 AIR SEPARATOR TANKS

External air separation tank shall have an internal design constructed of stainless steel and suitable for creating the required vortex and subsequent air separation. Tank shall be steel, constructed for, and tested to pressure-temperature rating of 862 ka at 66 degrees C (125 psi at 150 degrees F). Tank shall have tangential inlets and outlets connections, threaded for 50 mm (2 inches) and smaller and flanged for sizes 65 mm (2-1/2 inches) and larger. Air released from a tank shall be vented to the atmosphere or as indicated. Tank shall be provided with a blow-down connection.

Design to separate air from water and to direct released air to automatic air vent. Unit shall be of one piece cast-iron construction with internal baffles and two air chambers at top of unit; one air chamber shall have outlet to expansion tank and other air chamber shall be provided with automatic air release device. Tank shall be steel, constructed for, and tested to a ANSI Class 125 pressure-temperature rating.

2.11 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing equivalent chromium (CPR) is prohibited.

2.11.1 Water Analysis

Conditions of make-up water to be supplied to the condenser and chilled water systems were reported in accordance with ASTM D596 and are as indicated in the contract drawings and documents:

Date of Sample	
Temperature	degrees C (F)
Silica (Sino 2)	pp (mg/1)
Insoluble	pp (mg/1)
Iron and Aluminum Oxides	pp (mg/1)
Calcium (Ca)	pp (mg/1)
Magnesium (Mg)	pp (mg/1)
Sodium and Potassium (Nan and AK)	pp (mg/1)
Carbonate (HO 3)	pp (mg/1)
Sulfate (SO 4)	pp (mg/1)

Chloride (JCL)	pp (mg/1)
Nitrate (NO 3	pp (mg/1)
Turbidity	unit
pH	
Residual Chlorine	pp (mg/1)
Total Alkalinity	PM (me/1
Non-Carbonate Hardness	PM (me/1
Total Hardness	PM (me/1
Dissolved Solids	pp (mg/1)
Fluorine	pp (mg/1)
Conductivity	McMahon/cm

2.11.2 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.11.3 Glycol Solution

A 25 percent concentration by volume of industrial grade propylene glycol shall be provided in the chilled water. The glycol shall be tested in accordance with ASTM D1384 with less than 0.013 mm (0.5 mils) penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors shall not be used. The solution shall be compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.11.4 Water Treatment Services

The services of a company regularly engaged in the treatment of condenser or condenser and chilled water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the condenser or condenser and chilled water systems for a period of 1 year from the date of occupancy. The chemical treatment and services provided over the 1 year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.11.5 Chilled Water System

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.11.6 Condenser Water

The water treatment system shall be capable of automatically or continuously feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on varying system conditions. Continuous chemical feed systems shall continuously feed chemicals into the condenser water at a constant rate. The system shall be initially set manually based on the water analysis of the make-up water.

2.11.6.1 Chemical Feed Pump

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.11.6.2 Tanks

Two chemical tanks shall be provided. The tanks shall be constructed of high density polyethylene or stainless steel as indicated, with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.11.6.3 Injection Assembly

An injection assembly shall be provided at each chemical injection point along the condenser water piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the condenser water line.

2.11.6.4 Water Meter

Water meters shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the make-up water line, as indicated.

2.11.6.5 Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.11.6.6 Water Treatment Control Panel

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of stainless steel, unless otherwise indicated, with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light
(2) MAN-OFF-AUTO selector switch
(3) Indicating lamp for bleed-off valve
(4) Indicating lamp for each chemical feed pump
(5) Set point reading for each timer

2.11.6.7 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC suitable for the water treatment chemicals, unless otherwise indicated.

2.11.6.8 Sequence of Operation

The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the make-up water flow rate and a separate timer. The system shall contain an adjustable valve for continuous blow down. The flow rate from the appropriate chemical tanks shall be manually set at the metering pump for continuous chemical feed. The injection of the chemical required for biological control shall be controlled by a timer which can be manually set for proper chemical feed. Timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.11.6.9 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.11.6.10 Bleed Line

A bleed line with a flow valve of the needle-valve type sized for the flow requirement or fixed orifice shall be provided in the pump return to the tower. The bleed line shall be extended to the nearest drain for continuous discharge.

2.12 ELECTRICAL WORK

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

Provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors.

2.13 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

2.13.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided. The factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be in accordance with ASTM B117, and for that test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of 3 mm (0.125 inch) on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen.

If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C (120 degrees F), the factory painting system shall be designed for the temperature service.

2.13.2 Shop Painting Systems for Metal Surfaces

Clean, retreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 50 degrees C (120 degrees F) shall be cleaned to bare metal.

Where hot-dip galvanized steel has been cut, resulting surfaces with no galvanizing shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 50 Degrees C (120 Degrees F): Immediately after cleaning, the metal surfaces subject to temperatures less than 50 degrees C (120 degrees F) shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm (0.3 mil), one coat of primer applied to a minimum dry film thickness of 0.0255 mm (one mil); and two coats of enamel applied to a minimum dry film thickness of 0.0255 mm (one mil) per coat.

b. Temperatures Between 50 and 205 degrees C (120 and 400 degrees F): Metal surfaces subject to temperatures between 50 and 205 degrees C (120 and 400 degrees F) shall receive two coats of 205 degrees C(400 degrees F) heat-resisting enamel applied to a total minimum thickness of 0.05 mm (2 mils).

c. Temperatures Greater Than 205 Degrees C (400 degrees F): Metal surfaces subject to temperatures greater than 205 degrees C (400 degrees F) shall receive two coats of 315 degrees C (600 degrees F) heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm (2 mils).

2.14 FACTORY APPLIED INSULATION

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84.

Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.15 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, type or style, model or serial number on a plate secured to the item of equipment. The nameplate of the distributing agent will not be acceptable. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.16 RELATED COMPONENTS/SERVICES

2.16.1 Drain and Make-Up Water Piping

Requirements for drain and make-up water piping and backflow preventer is specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.16.2 Cathodic Protection

Requirements for cathodic protection systems is specified in Section 26 42 14.00 10 CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE) Section 26 42 17.00 10 CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT).

2.16.3 Field Applied Insulation

Requirements for field applied insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.16.4 Field Applied Insulation

Requirements for field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as supplemented and modified by this specification section.

2.16.5 Field Painting

Requirements for painting of surfaces not otherwise specified, and finish painting of items only primed at the factory, are specified in Section 09 90 00PAINTS AND COATINGS.

2.16.5.1 Color Coding

Requirements for color coding for piping identification are specified in Section 09 90 00 PAINTS AND COATINGS.

2.16.5.2 Color Coding For Hidden Piping

A color coding scheme for locating hidden piping shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

PART 3 EXECUTION

3.1 INSTALLATION

Cut pipe accurately to measurements established at the jobsite, and work into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted without written approval. Cut pipe or tubing square, remove burrs by reaming, and fashion to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.1 Welding

Provide welding work specified this section for piping systems in conformance with ASME B31.9, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, brazers, brazing operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

3.1.1.1 Employer's Record Documents (For Welding)

Submit for review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.9.

a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.

b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.

c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification section.

3.1.1.2 Welding Procedures and Qualifications

a. Specifications and Test Results: Submit copies of the welding procedures specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.

b. Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

3.1.1.3 Examination of Piping Welds

Conduct non-destructive examinations (NDE) on piping welds and brazing and verify the work meets the acceptance criteria specified in ASME B31.9. NDE on piping welds covered by ASME B31.9 is visual inspection only. Submit a piping welds NDE report meeting the requirements specified in ASME B31.9.

3.1.1.4 Welding Safety

Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

3.1.2 Directional Changes

Make changes in direction with fittings, except that bending of pipe 100 mm (4 inches) and smaller is permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees is not permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.

3.1.3 Functional Requirements

Pitch horizontal supply mains down in the direction of flow as indicated. The grade shall not be less than 2 mm in 1 m (1 inch in 40 feet). Reducing fittings shall be used for changes in pipe sizes. Cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the system.

Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 65 mm (2-1/2 inches) or less in diameter, and with flanges for pipe 80 mm (3 inches) and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges.

Piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.4 Fittings and End Connections

3.1.4.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.4.2 Brazed Connections

Brazing, AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.4.3 Welded Connections

Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.9. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.4.4 Grooved Mechanical Connections

Prepare grooves in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.4.5 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.4.6 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for the intended application.

3.1.5 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.6 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.7 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.8 Flexible Pipe Connectors

Connectors shall be attached to components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.9 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm (1 inch).

3.1.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as supplemented and modified in this specification section. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.10.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.10.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.10.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C (60 degrees F) or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C (60 degrees F). A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.1.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg (50 pounds) shall have the excess hanger loads suspended from panel points.

3.1.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m (15 feet), not more than 2.4 m (8 feet) from end of risers, and at vent terminations.

3.1.10.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.10.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.10.10 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.10.11 Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified under Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as shown on the drawings. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.1.10.12 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.1.11 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m (5 feet) on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 600 mm (2 feet) on each side of the joint.

3.1.12 Pipe Anchors

Anchors shall be provided where indicated. Unless indicated otherwise, anchors shall comply with the requirements specified. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required.

Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal.

3.1.13 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 1.0 mm (20 gauge). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm (1/2 inch) depth. Sleeves shall not be installed in structural members.

3.1.13.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar.

In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors.

Integral cast-in collar type sleeve shall be flashed as indicated with not less than 100 mm (4 inches) of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 100 mm (4 inches) of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer.

Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.1.13.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 6.35 mm (1/4 inch) all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

3.1.13.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 5.17 kg/sq. m (0.17 ounce) copper sleeve, or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange.

Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 inches) above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut.

   After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.13.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.1.13.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.14 Access Panels

Access panels shall be provided where indicated for all concealed valves, vents, controls, and additionally for items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS Section 05 51 33 METAL LADDERS Section 05 52 00 METAL RAILINGS Section 05 51 00 METAL STAIRS.

3.2 ELECTRICAL INSTALLATION

Install electrical equipment in accordance with NFPA 70 and manufacturer's instructions.

3.3 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.4 FIELD TESTS

Field tests shall be conducted in the presence of the QC Manager or his designated representative to verify systems compliance with specifications. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor.

3.4.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the tests shall be properly isolated.

3.4.2 Pressure Tests

Each piping system shall be hydrostatically tested at a pressure not less than 1297 kPa (gage) (188 psig) for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a currently calibrated test pressure gauge. Leaks shall be repaired and piping retested until test requirements are met. No leakage or reduction in gage pressure shall be allowed.

Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

Submit for approval pressure tests reports covering the above specified piping pressure tests; describe the systems tested, test results, defects found and repaired, and signature of the pressure tests' director. Obtain approval from the QC Manager before concealing piping or applying insulation to tested and accepted piping.

3.4.3 Condenser Water Quality Test Reports

The condenser water system shall be analyzed by the water treatment company a minimum of once a month for a period of one year after system acceptance. Submit for approval the specified condenser water quality test reports. The analysis and resulting reports shall include the following information recorded in accordance with ASTM D596.

Date of Sample	
Temperature	degrees C (F)
Silica (Sino 2)	pp (mg/1)
Insoluble	pp (mg/1)
Iron and Aluminum Oxides	pp (mg/1)
Calcium (Ca)	pp (mg/1)
Magnesium (Mg)	pp (mg/1)
Sodium and Potassium (Nan and AK)	pp (mg/1)
Carbonate (HO 3)	pp (mg/1)
Sulfate (SO 4)	pp (mg/1)
Chloride (JCL)	pp (mg/1)
Nitrate (NO 3	pp (mg/1)
Turbidity	unit
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	epm (meq/1)

Non-Carbonate Hardness	epm (meq/1)
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	microhm/cm

3.4.4 Related Field Inspections and Testing

3.4.4.1 Piping Welds

Examination of Piping Welds is specified in the paragraph above entitled "Examination of Piping Welds".

3.4.4.2 HVAC TAB

Requirements for testing, adjusting, and balancing (TAB) of HVAC water piping, and associated equipment is specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Coordinate with the TAB team, and provide support personnel and equipment as specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC to assist TAB team to meet the TAB work requirements.

3.5 INSTRUCTION TO GOVERNMENT PERSONNEL

Furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the chilled water, chilled-hot water, and condenser water piping systems. Instructors shall be thoroughly familiar with all parts of the installation and shall be instructed in operating theory as well as practical operation and maintenance work. Submit a lesson plan for the instruction course for approval. The lesson plan and instruction course shall be based on the approved operation and maintenance data and maintenance manuals.

Conduct a training course for the operating staff and maintenance staff selected by the Contracting Officer. Give the instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be one man-day. Use approximately half of the time for classroom instruction and the other time for instruction at the location of equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

3.6 ONE-YEAR INSPECTION REPORT FOR COOLING WATER

At the conclusion of the one year period, each connecting cooling tower and liquid chiller condenser inspect for problems due to corrosion, scale, and biological growth. If the equipment is found not to conform to the manufacturers recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

-- End of Section --

SECTION 23 65 00

COOLING TOWERS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.13	(2005; R 2010) Methods for the Measurement of Sound Pressure Levels in Air (ASA 118)

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C67	(2014) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2996	(2001; E 2007; R 2007) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D520	(2000; R 2011) Zinc Dust Pigment

ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials

COOLING TECHNOLOGY INSTITUTE (CTI)

CTI ATC-105	(2000) Acceptance Test Code
CTI ESG-114	(2007) Design of Cooling Towers with Douglas Fir Lumber
CTI STD-111	(2009) Gear Speed Reducers
CTI STD-134	(2007) Plywood for Use in Cooling Towers
CTI Std-103	(2007) Redwood Lumber Specifications
CTI Std-112	(2009) Pressure Preservative Treatment of Lumber
CTI Std-137	(2013) Fiberglass Pultruded Structural Products for Use in Cooling Towers
CTI Std-201	(2011) Standard for the Certification of Water Cooling Tower Thermal Performance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2014) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 214	(2011; Errata 2011) Standard on Water-Cooling Towers
NFPA 255	(2006; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

REDWOOD INSPECTION SERVICE (RIS) OF THE CALIFORNIA REDWOOD ASSOCIATION (CRA)

RIS Grade Use	(1998) Redwood Lumber Grades and Uses

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J534	(2008) Lubrication Fittings

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA G-5	(2011) Western Lumber Grading Rules

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cooling Towers; G

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Posted Instructions; G

Posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Demonstrations; G

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions; G

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Packaged cooling tower - installation instructions; G

Field-erected cooling tower - installation instructions; G

Packaged cooling tower - field acceptance test plan; G

Field-erected cooling tower - field acceptance test plan; G

Packaged cooling tower - field acceptance test report; G

Field-erected cooling tower - field acceptance test report; G

SD-07 Certificates

Service Organization

Cooling Tower

SD-08 Manufacturer's Instructions

Packaged cooling tower - installation instructions

Field-erected cooling tower - installation instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1. Catwalk, ladder, and guardrail shall be provided where indicated and in accordance with Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS Section 05 51 33 METAL LADDERS Section 05 52 00 METAL RAILINGS Section 05 51 00 METAL STAIRS.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.6 Warranty

In addition to the warranty requirements specification in Division 00, Contract Requirements, the following major components of the cooling tower shall be covered by a warranty of a duration period of five years: fans, fan drives, electric motors, cold water basin, basin heater.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard commercial catalogued products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship.

The standard products shall have been in satisfactory commercial or industrial use in field service for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. This 6000 hour record shall not include any manufacturer's prototype or factory testing.

Records of satisfactory field use shall be completed by a product that had been, and presently is, sold, or offered for sale on a commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including cooling towers, cooling tower gear drive assemblies, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life. Plates shall be fixed in prominent locations.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

e. Where two-speed or variable speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW 10 hp or less and adjustable frequency drives for larger motors.

2.4 COOLING TOWER MATERIALS

2.4.1 Lumber

2.4.1.1 Douglas Fir

CTI ESG-114, WWPA G-5, Grade B and better, Industrial Clear. Douglas fir shall have a preservative treatment in accordance with CTI Std-112.

2.4.1.2 Plywood

CTI STD-134, Exterior Grade, type and thickness as specified for the application.

2.4.1.3 Pressure Treated Lumber

Pressure treated lumber shall be in accordance with CTI Std-112. Wood exposed as the result of notching, cutting, or drilling shall be saturated with the preservative.

2.4.1.4 Redwood

CTI Std-103, RIS Grade Use California Redwood, clear of all hearts.

2.4.2 Fiberglass Reinforced Plastic (FRP)

FRP components shall be inert, corrosion resistant, and fire-retardant with a thickness of 3.66 kg/square meter (12 ounces per square foot). FRP components shall contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3. Components manufactured of polystyrene will not be permitted.

2.4.3 Zinc-Coated Steel

Components fabricated of zinc-coated steel shall be not lighter than 16 gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153/A153M and ASTM A123/A123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square meter (2.5 ounces per square foot) of surface. Galvanized surfaces damaged due to welding shall be coated with zinc rich coating conforming to ASTM D520, Type 1.

2.4.4 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D1784, Type I, Grade 1 with a flame spread rating of 25 or less per ASTM E84.

2.4.5 Stainless Steel Sheets

Type 304.

2.4.6 Concrete

Concrete shall conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted.

2.4.7 Hardware

Bolts shall be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt shall be provided with neoprene and cadmium-plated steel washers under the heads. Nails shall be silicon bronze, commercial bronze, or stainless steel. Hardware shall meet the salt-spray fog test as defined by ASTM B117. Angle brackets and similar parts shall be cast iron or zinc-coated steel. Zinc coatings shall conform to ASTM A153/A153M and ASTM A123/A123M, ASTM A653/A653M, as applicable, and shall have an extra heavy coating of not less than 0.76 kg/square meter (2.5 ounces per square foot) of surface. Nails shall be silicon bronze, commercial bronze, or stainless steel. Subject hardware to a salt-spray fog test in accordance with ASTM B117. No signs of corrosion shall be evident after 1,000 hours continuous exposure to a 5 percent salt spray.

2.5 COOLING TOWERS

2.5.1 Factory Assembled Towers

2.5.1.1 Description

The cooling tower shall be of the induced mechanical draft or forced mechanical draft type. The cooling tower shall include frames and casings, louvers, drift eliminators, partitions, windbreak baffles, drift-check walls, cold water basin equipment, fans and fan walls, blowers, drives, electric motors, access doors, working platforms, inspection plates, and panels.

2.5.1.2 Construction

Tower shall be constructed to withstand a wind pressure of not less than 1.44 kilopascal (kPa) (30 psf) on any external surface. Fan deck shall be constructed to withstand a live load of not less than 2.87 kPa (60 psf) in addition to the concentrated or distributed loads of equipment mounted on the fan deck. A 15 percent increased loading shall be included for ice or snow load.

The hot water distribution system shall be of the open basin gravity feed type or the pressurized spray header type design.

2.5.1.3 Tower Frame and Louvers

Provide frame constructed from galvanized steel. Intermediate structural members shall be provided for rigidity and support of casings, louvers, fill, distribution systems, fan decks, and other equipment. Inlet air louvers shall permit free air passage but no splashout, and shall be designed to prevent debris and sunlight from entering the cold water basin.

2.5.1.4 Air Inlet And Discharge Connections

On forced draft centrifugal type units, the air inlet and discharge connections shall have flanged or lipped projections for connecting to ductwork.

2.5.1.5 Fill

The fill shall support expected loads without sag or failure and arranged to effectively break up the water. The fill shall be manufactured and performance tested by the cooling tower manufacturer. The fill shall be of the materials as specified. Polyvinyl chloride fill is suitable for inlet temperatures to 51.7 degrees C (125 degrees F) on cross flow type units and temperatures to 54.4 degrees C (130 degrees F) on counterflow type units. Chlorinated polyvinyl chloride(CPVC) fill shall be used for applications where inlet temperatures are greater than 54.4 degrees C (130 degrees F).

2.5.1.6 Drift Eliminators

Provide drift eliminator sections designed and arranged to effectively trap water droplets entrained in the discharge airstream. Sections shall be assembled in easily removable sections for forced mechanical drift tower and counterflow induced mechanical draft tower.

2.5.1.7 Cold Water Basin Equipment.

Include sump with removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 13 mm (1/2 inch) pipe size shall be the balanced piston type. Valve seats and disks shall be replaceable. Electric water level control shall be provided.

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.1.8 Fans, Blowers, and Drives.

The towers shall have propeller-type fans having not less than four metal blades or squirrel-cage, centrifugal-type blowers, as applicable.
Fans and blowers shall be designed and constructed to withstand 50 percent overspeed above normal maximum operating speeds.

If belt drives are utilized, multi-grooved solid back single belt design shall be used to avoid uneven belt stretch. Adjustment shall be provided for belt tension and drive centers. Belt drives shall be designed and constructed for 150 percent overload.

Sheaves located in the airstream shall be corrosion-resistant material. Shafting for gear drives shall have flexible-type couplings requiring no lubrication.

The gear assemblies shall be enclosed in an oil filled housing provided with fill and drain plugs.

2.5.1.9 Tower Piping

Plastic piping shall be not less than schedule 40 and conform to ASTM D2996. Fittings for other piping materials shall be of the same material or equal and of the same class and grade as the pipe.

2.5.1.10 Electric Motors

Requirements are specified in paragraph ELECTRICAL WORK.

2.5.1.11 Vibration Cutout Switch.

Provide electronic vibration cutout switch with auxiliary contacts in a protected position and most effective location, interlocked with the fan wiring to electrically open the motor circuit under excessive fan vibration.

2.5.1.12 Performance

The factory assembled tower shall have Cooling Tower Institute certification that, in accordance with CTI Std-201, the cooling tower will perform thermally at the rating published by the tower manufacturer in his copyrighted literature.

2.5.1.13 Sound Power Level

Sound power levels, in decibels (dB)with a reference pressure of 0.0002 microbars, of the cooling tower shall be not greater than the maximum permitted dB levels for the designated octave band as set forth in Table I or Table II. The sound power level data for the cooling tower shall have been verified in tests conducted in accordance with ASA S1.13.

Table I. Sound Power Level For Induced Mechanical Draft Type

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

Table II. Sound Power Level For Forced Mechanical Draft Type

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

2.5.1.14 Drift Loss

Drift loss shall be not greater than 0.005 percent of the water circulated.

2.5.2 Lubrication

The lubricating points shall be extended to the outside of the unit for easy accessibility. Hydraulic lubrication fittings shall be in accordance with SAE J534. Where use of high pressure lubricating equipment, 6894 kPa (1000 psi) or higher, will damage grease seals or other parts, a suitable warning shall be affixed to the equipment in a conspicuous location.

2.5.3 Factory Finish System

Manufacturer's standard factory finish system shall be provided.

Factory painting system or galvanized metal shall have been proven to withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117.

For that salt-spray fog test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 3 mm (0.125 inch) on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C (120 degrees F), the factory painting system be designed for the temperature service and shall have been proven to pass the specified salt-spray test.

2.5.4 Field-Assembled Cooling Towers

Factory fabricated, factory-assembled towers which are shipped to the job site in separate cells or modules shall be provided with all appropriate manufacturer's hardware for assembly in the field. Factory fabricated, field-assembled towers shall be assembled and adjusted at the job site by a factory representative.

2.5.4.1 Framework, Casing, and Supports

Towers shall be designed and constructed to withstand a wind pressure of not less than 1.4 kPa 30 pound-force per square foot (psf) on external surfaces. A 15 percent increased loading shall be included for ice or snow load. Air inlet and discharge terminations shall have flanged or lipped projections for connecting ductwork. Framework, structural supports, and equipment supports shall be zinc-coated steel, Type 304 stainless steel, air-entrained concrete FRP, or lumber. Casing (exterior enclosing walls) shall be constructed of zinc-coated steel Type 304 stainless steel air-entrained concrete FRP or lumber. Framework design for wood towers shall conform to requirements of CTI Std-103 for redwood construction and CTI ESG-114 for Douglas fir construction. Notching structural wood members may be permissible only if the members are increased proportionately in size to provide equivalent strength. Materials provided for framework, casings and equipment supports shall be compatible. Structural supports shall be provided in accordance with the recommendations of the manufacturer of the tower unless otherwise indicated. Cold-pour concrete joints in vertical walls shall have a continuous water-stop stripping of molded polyvinyl plastic (150 mm (6 inch) dumbbell).

2.5.4.2 Foundations

Cooling tower foundations shall meet the requirements of the cooling tower manufacturer and wind and seismic loads, wind and seismic loads and be as indicated. Foundation design shall be based on the load conditions and soil bearing value indicated. Foundation calculations shall be submitted with the equipment drawings.

2.5.4.3 Stairways and Ladders

Provide stairs, 60-degree ship ladders or straight-rung ladders of standard design, starting at ground level and extending as high as required to gain access to fan decks and water distribution systems. Stairways and ladders shall be hot-dip, zinc-coated steel. Ladders higher than 3.66 meters (12 feet) shall have a safety cage.

2.5.4.4 Handrailings

Steel handrailings shall be not less than 1067 mm (42 inches) high around the exterior of each working surface that is 3.66 m (12 feet) or more above the ground, roof, or other supporting construction. Railings shall be not smaller than 32 mm (1-1/4 inch) zinc-coated steel pipe with standard zinc-coated steel railing.

2.5.4.5 Access Doors

Each tower shall be provided with access doors at grade level to provide entry to the interior for service maintenance without removal of the fill. Doors shall be provided on each endwall of each cooling tower cell. Frame and brace access doors to prevent damage when opening and closing. Doors shall be located adjacent to float controls.

2.5.4.6 Louvers

Air inlets for each cooling tower shall be provided with individually removable louvers arranged to prevent the escape of water. Louvers shall be zinc-coated steel, Type 304 stainless steel, FRP, or lumber. Materials provided for casings and louvers shall be compatible; one material shall not produce stains upon the other. Louvers constructed of lumber shall be of a thickness to withstand alternate wetting and drying without cracking or splitting. Air intakes shall be provided with 25 mm (1 inch) zinc-coated steel mesh.

2.5.4.7 Fan Deck and Cylinder

Each fan shall be mounted in a fan cylinder (or stack) to elevate the fan discharge air. Total extension height shall not exceed the fan diameter. Each fan cylinder shall be provided with a zinc-coated steel 2.75 mm (12 gauge) wire mesh securely mounted to the top of the cylinder in accordance with manufacturer's recommendations. Fan decks shall be designed to withstand a live load of not less than 1.9 kPa (40 psf) in addition to the concentrated or distributed loads of equipment mounted on the fan decks. Fan deck and cylinders shall be constructed of zinc-coated steel, lumber, Type 304 stainless steel, or FRP and be compatible with the entire tower construction. Fan deck shall be constructed of precast, reinforced lightweight concrete, in multiple sections, forming a complete, vibration-free base for mounting fan, speed reducer, drive shaft, motor, and fan stacks. Fan cylinders (or stacks) shall be constructed of precast, reinforced lightweight concrete in multiple sections, constrained with bands of zinc-coated steel conforming to ASTM A123/A123M, not less than 3 by 75 mm (1/8 by 3 inches), and bolted to form a compressive load on stack perimeter. Fan cylinder shall be secured in place on the fan deck with Class A mortar.

2.5.4.8 Fans

Fans shall be the centrifugal or adjustable-pitch propeller type, constructed of zinc-coated steel, Type 304 stainless steel, aluminum or an aluminum alloy, or FRP. Propeller type shall have a maximum tip speed of 330 m/minute (10,800 fpm). Fan blade assembly shall be both statically and dynamically balanced after assembly of the cooling tower. Fan hub shall be constructed of zinc-coated steel, stainless steel, or cast aluminum with adequate surface protection against corrosion. Complete fan assembly (fan and mounting) shall be designed to give maximum fan efficiency and long life when handling saturated air at high velocities. Each cooling tower fan shall be provided with a ball and pedestal type vibration limit switch which shall stop the corresponding fan motor in the event of sensing excessive fan vibration.

2.5.4.9 Speed Reducers Gears and Drive Shaft

Speed reducer gears shall be rated in accordance with CTI STD-111. Gear reducers shall be of the spiral bevel, single reduction, or spiral or helical, double reduction type. Reducer shall be mounted in accordance with manufacturer's recommendations. Each reducer shall be provided with an oil level cutoff switch interlocked to the fan motor. Each reducer shall be provided with an oil level sight glass, fill, drain, and vent lines located in a readily accessible position. Drive shafts shall be the full floating type with flexible couplings at both ends and have a service factor of 1.0 or greater. Drive shafts shall be of stainless steel, fitted each end with flexible couplings (stainless steel plate type). Each drive shaft shall be provided with a galvanized steel guard, to prevent damage to surrounding equipment in case of shaft failure. Provision shall be made for lubrication of all bearings. Bearings shall be accessible to the extent that each bearing can be lubricated without dismantling fan.

2.5.4.10 Electric Motors

Each motor shall be a single speed or two speed, as indicated, totally enclosed, insulation Class B, NEMA Design B, continuous-rated type which conforms to NEMA MG 1. Motors shall have totally enclosed enclosures and be located outside the discharge airstream, unless otherwise indicated on contract drawings. Motors shall be mounted according to manufacturer's recommendations. Two-speed motors shall have a single winding with variable torque characteristics. Motors shall be provided specifically for either pump or fan application and shall comply with the requirements of paragraph ELECTRICAL WORK.

2.5.4.11 Cold Water Basin

Basin shall be completely watertight and constructed of zinc-coated steel. Basin shall be constructed and installed to ensure that air will not be entrained in outlets when operating and no water will overflow on shutdown. Each individual sump shall be provided with an individual outlet. Each outlet shall be provided with a 1/2 inch mesh, zinc-coated steel wire securely mounted to prevent trash from entering the outlet. Each basin shall be provided with overflow and valved drain connections. Each basin shall be provided with a float-controlled, makeup water valve as indicated. The makeup water shall discharge not less than 50 mm (2 inches) or two pipe diameters, whichever is greater, above the top of the basin. Basin floor slab shall be made in a continuous pour. A continuous water-stop stripping of molded polyvinyl plastic (150 mm (6 inch) dumbbell) shall be located on the centerline position of the basin wall section/floor slab intersection, and at all other cold pour joints. Basin wall sections shall be made in a second continuous pour, contain the necessary reinforcing steel as submitted by the manufacturer and approved, and be arranged to interlock with the water-stop seal in the floor slab, forming a completely waterproof basin.

2.5.4.12 Electric Basin Heater

Heater shall be the electric immersion type with water-tight junction boxes mounted in the basin with sufficient capacity to maintain the basin water temperature above 4.4 degrees C (40 degrees F) at an ambient temperature of -6.6 degrees C (20 degrees F). Heater shall be complete with control thermostat, transformer, contactor, and low water level heater protection.

2.5.4.13 Hot Water Distribution System

Water distribution shall be the gravity-flow type system which distributes waters evenly over the entire fill surface, unless otherwise indicated on contract drawings. Each tower cell shall be designed so that a water flow of 140 percent capacity will not cause overflowing or splashing. The distribution system for each cell shall include adjustable flow control valves. The entire distribution system shall be self-draining and nonclogging. Piping shall be either cast iron, ductile iron, threaded-glass-fiber reinforced epoxy pipe, polypropylene, PVC or Schedule 80 black steel.

a. Gravity-Flow System: System shall be provided with open basins which include a splash box or baffles to minimize splashing of incoming hot water and holes that evenly distribute the water over the entire decking area. Holes used in a water basin shall be provided with ceramic or plastic orifice inserts.

b. Pressurized-Flow System: System shall include piping, fittings, branches, and spray nozzles. Spray nozzles shall be stainless steel, bronze, polypropylene, or high-impact plastic. Nozzles shall be cleanable, nonclogging, removable, and spaced for even distribution.

c. Basin Cover: Hot water distribution basins shall be provided with the tower manufacturer's standard removable, zinc-coated steel, stainless steel, or FRP covers, as indicated on contract drawings. Covers shall prevent airborne debris from entering the basin.

2.5.5 Drift Eliminators

Eliminators shall be provided in the tower outlet to limit drift loss to not over 0.005 percent of the circulating water rate. Eliminators shall be constructed of not less than 10 mm (3/8 inch) lumber or polyvinyl chloride (PVC). Eliminators shall be of the multi-pass zigzag type, assembled into sections making a strong, stable unit. Eliminators sections shall be supported on PVC or FRP tee sections. Tee sections shall be suspended with 6.35 mm (1/4 inch) brass rods connected to stainless steel clips embedded in the bottom side of the roof deck at the time of casting. Stainless steel clips shall be supplied by cooling tower manufacturer for installation by Contractor at time of roof deck pour. Eliminators may be supported by brass or stainless steel suspension rods from the fan deck or supported directly on concrete beams.

2.5.6 Cold Water Basin Equipment.

Include sump with removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 13 mm (1/2 inch) pipe size shall be the balanced piston type. Valve seats and disks shall be replaceable. Electric water level control shall be provided.

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.7 Fill (Heat Transfer Surface)

Tower fill shall be the splash or film type. Fill material shall be free to expand or contract without warping or cracking. No plasticized wood cellulose shall be provided for fill material. Fill shall be removable or otherwise made accessible for cleaning. Space supports shall be corrosion resistant and shall prevent warping, sagging, misalignment, or vibration of the fill material. Fill material and supports shall be designed to provide for an even mixing of air and water. Fill material shall be constructed of aluminum stainless steel tile of multi-cell design, set without mortar PVC formed sheets, zinc-coated steel, or lumber in a pattern, and of sufficient height to meet the performance specifications. Tile fill shall be vitreous, with a low water absorption that will pass a freeze-thaw test conducted in accordance with ASTM C67. Tile fill shall have a minimum crushing strength of 13.8 MPa (2,000 psi) over the gross area of the tile when the load is applied parallel to the cells as tested in accordance with ASTM C67. Cast iron tee section lintels supporting the tile fill shall conform to ASTM A48/A48M, Class 25, 3.2 mm (1/8 inch) additional thickness for corrosion. Lintels shall be designed with a safety factor of 2 minimum.

2.5.8 Fire Safety

Towers shall conform to NFPA 214. Fire hazard rating for plastic impregnated materials shall not exceed 25. Plastics shall not drip or run during combustion. Fire hazard ratings shall be in accordance with ASTM E84 or NFPA 255.

2.6 FABRICATION

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.7 SUPPLEMENTAL COMPONENTS/SERVICES

2.7.1 Condenser Water Piping and Accessories

Condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.7.2 Cooling Tower Water Treatment Systems

Cooling tower water treatment systems shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT AND CONDENSER WATER PIPING SYSTEMS.

PART 3 EXECUTION

3.1 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.2 INSTALLATION

Installation of cooling tower systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with NFPA 70, and in compliance with the manufacturer's written installation instructions, including the following:

(1) Packaged cooling tower - installation instructions

(2) Field-erected cooling tower - installation instructions

3.2.1 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.3 RELATED FIELD TESTING

3.3.1 Test Plans

a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

(1) Packaged cooling tower - field acceptance test plan

(2) Field-erected cooling tower - field acceptance test plan

Field acceptance test plans shall developed by the cooling tower manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance test plans shall be the plan and procedures followed for the field acceptance tests of the cooling towers and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls factory prewired or external controls for the equipment provided under SECTION 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMSor SECTION 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS SECTION 23 09 23.13 20.

c. Prerequisite testing: Cooling towers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Tower manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

Tower manufacturer shall identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

f. Job specific: Each test plan shall be job specific and shall address the particular cooling towers and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.4 Testing

a. Each cooling tower system shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

1. Packaged cooling tower - field acceptance test report

2. Field-erected cooling tower- field acceptance test report

b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

g. Towers with thermal performance not CTI certified to CTI Std-201 shall have their thermal performance verified by field testing that meets the requirements of CTI ATC-105

-- End of Section --

SECTION 23 82 01.00 10

WARM AIR HEATING SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.47/CSA 2.3	(2012) Gas-Fired Central Furnaces
ANSI Z21.66/CGA 6.14	(1996; R 2001) Automatic Vent Damper Devices for Use with Gas-Fired Appliances

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012; Errata 2013; INT 1 2014) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D3359	(2009; E 2010; R 2010) Measuring Adhesion by Tape Test

ASTM D520	(2000; R 2011) Zinc Dust Pigment

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2014) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2013) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 31	(2011) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2015) National Fuel Gas Code
NFPA 701	(2010) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2015) Standard for the Installation of Warm Air Heating and Air Conditioning Systems

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH116	(2002, 5th Ed) Fibrous Glass Duct Construction Standards

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition
SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

UNDERWRITERS LABORATORIES (UL)

UL 1738	(2010; Reprint Nov 2014) Venting Systems for Gas-Burning Appliances, Categories II, III and IV
UL 181	(2013) Factory-Made Air Ducts and Air Connectors
UL 296	(2003; Reprint Sep 2013) Oil Burners

UL 441	(2010; Reprint Jun 2014) Gas Vents
UL 555	(2006; Reprint May 2014) Standard for Fire Dampers
UL 641	(2010; Reprint Jun 2013) Type L Low-Temperature Venting Systems
UL 727	(2006; Reprint Oct 2013) Standard for Oil-Fired Central Furnaces
UL 900	(2004; Reprint Feb 2012) Standard for Air Filter Units
UL Bld Mat Dir	(2012) Building Materials Directory
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2012) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

Provide electrical motor-driven equipment specified complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics and enclosure type shall be as shown. Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Provide motor starters complete with thermal overload protection and other appurtenances necessary. Each motor shall be in accordance with NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW (10 hp) or less. Use adjustable frequency drives for larger motors.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are forinformation only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G

SD-03 Product Data

Spare Parts

Furnace

Tests

System Diagrams; G

Qualifications

Field Training

SD-06 Test Reports

Tests

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals

1.4 QUALITY ASSURANCE

Submit documentation demonstrating qualifications and successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than one month prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 12 months operation, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 year(s) of service.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

2.1.2 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. As applicable, affix an ENERGY STAR label to the product.

2.2 SELF-CONTAINED FURNACE

Provide a furnace which is a manufacturer's standard, self-contained, forced circulated air heating type furnace as indicated. Furnace and furnace components shall be completely factory-assembled and wired. Furnace casing shall be factory insulated and be compatible with the operating temperatures. Furnace shall be provided with removable service panels which allow access to all internal components requiring cleaning, servicing, or adjustment. Submit manufacturer's documentation demonstrating that the included model is Energy Star labeled or meets current FEMP efficiency requirements.

2.2.1 Gas-Fired Unit

Gas-fired furnace shall be the conventional or high efficiency, condensing type in accordance with ANSI Z21.47/CSA 2.3. Furnace design shall be certified by the AMERICAN GAS ASSOCIATION LABORATORIES (AGA). Furnace shall have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of not less than 90 percent.

2.2.2 Oil-Fired Unit

Oil-fired furnace shall be in accordance with UL 727 and have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of 83 percent.

2.3 FURNACE COMPONENTS

2.3.1 Oil-Burning Components

The equipment shall include the oil burner motor, ignition equipment safety devices, and accessories necessary for a full automatic system that conforms to UL 296. Oil-fired units equipped with programming controls shall be furnished with low oil-pressure switches in the fuel supply piping. Oil-fired units not equipped with programming controls shall be equipped with a delayed opening or shutoff valve. The valve shall automatically delay delivery of oil to the burner until such time as the combustion air fan and, when applicable, the induced draft fan are operated at rated speed.

2.3.2 Gas-Burning Components

Gas-burning equipment shall include the gas burners, ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, when applicable, and accessories necessary for a fully automatic system that is listed in CSA Directory. Gas-fired units equipped with programming controls shall be furnished both with high and with low gas supply pressure switches in the fuel supply piping.

2.3.3 Ignition Systems

2.3.3.1 Gas-Fired Units

Ignition systems shall be of the direct spark, hot surface, or interrupted intermittent type with automatic electric ignition. The pilots shall be of the electrically-ignited proven type. Continuous pilots will not be permitted. Burner shall be designed in accordance with NFPA 54 and located so that parts are protected against overheating. Provisions shall be made in the burner housing for inspection of the pilot flame.

2.3.3.2 Oil-Fired Units

Ignition systems for oil-fired units shall be of the direct-electric spark type or interrupted type in accordance with UL 296.

2.3.4 Supply Blowers

Blowers shall be centrifugal type. Blowers shall be statically and dynamically balanced. Lubrication points shall be located or extended, as required, to provide ready access for periodic lubrication. The direction of rotation shall be clearly and permanently marked on each blower housing. Blower speeds shall be single, or multispeed, as indicated, to provide the specified range of air temperature rises. Direct-drive blowers may have multiple speed motors to change blower speed. Belt-drive blowers shall be provided with an adjustable base and guard or enclosed in the unit casing. The belt drive shall be designed in accordance with the applicable Rubber Manufacturer's Association (RMA) power transmission belt specifications, with a service factor of at least 1.2. Shafts shall be supported by a minimum of two self-aligning bearings. Blower speed shall be adjusted by the use of variable pitch drive sheaves.

2.3.5 Vents for Conventional furnaces

A 8 mm (0.3125 inch) diameter hole shall be provided in the vent stack not greater than 152 mm (6 inches) from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack shall be provided complete with bird screen and rain hood.

2.3.5.1 Gas-Fired Units

Vent piping shall be in accordance with UL 441, Type B or Type BW. Vent shall conform to NFPA 211 and NFPA 54. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.3.5.2 Oil-Fired Units

Vent piping shall be in accordance with UL 641, Type L. Vent shall conform to NFPA 211. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.3.6 Vents for High Efficiency Furnaces

Direct venting shall be used for condensing type furnaces. Both the air intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer. A separate combustion air intake vent and exhaust shall be provided for each furnace. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.3.6.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent shall be suitable for the temperature at the furnace combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.3.6.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel in accordance with UL 1738 and the furnace manufacturer's recommendations. The exhaust vent shall be suitable for the maximum anticipated furnace exhaust temperature and shall withstand the corrosive effects of the condensate. A 8 mm (0.3125 inch) diameter hole shall be provided in the stack not greater than 152 mm (6 inches) from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.4 AIR CONDITIONING EQUIPMENT

Cooling coils, condensers and related equipment shall be as specified in Section 23 82 02.00 10 UNITARY HEATING AND COOLING EQUIPMENT.

2.5 CONTROLS

Furnace controls shall be provided by the furnace manufacturer as an integral part of the furnace. Electronic controls shall be provided. The controls shall allow for single stage, two stage or variable speed operation, as indicated on drawings. Controls shall be provided as specified in Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

2.6 AUTOMATIC VENT DAMPERS

Automatic vent dampers shall be provided in the vents of all gas burning equipment that uses indoor air for combustion. Vent dampers shall conform to ANSI Z21.66/CGA 6.14.

2.7 HUMIDIFIERS

2.7.1 Steam Spray Type

Steam spray humidifiers shall inject steam directly into the surrounding air or air stream as indicated. Single grid humidifiers shall consist of a single copper distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condenser traps shall be field-installed. Enclosed grid shall be housed in a copper enclosure with a build-in condensate drain connection. Exposed grid shall be wick wrapped. Package type steam spray humidifiers shall be equipped to trap out and to re-evaporate condensate and to supply dry steam to a single distribution grid. Grid shall be steam jacketed and condensate drained. Unit shall trap excess condensate to return system. Package type steam spray humidifiers shall have modulating electric, electronic, or pneumatic steam control valve, as indicated. Steam spray humidifiers shall be rated for humidifying capacity in kg (pounds) of steam per hour and at steam pressure as indicated.

2.7.2 Steam Diffuser Type

Diffuser units shall be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. All materials shall be noncorrosive materials.

2.7.3 Operation

Humidifier shall be controlled by a manually adjustable humidistat located in living spaces with sensing bulb in return or supply. Humidifier shall operate when the furnace operates. Humidistat shall be calibrated in percent relative humidity and shall be furnished by the humidifier manufacturer.

2.8 AIR FILTERS

Air Filters shall be listed in accordance with requirements of UL 900.

2.8.1 Replaceable Media filters

Replaceable media filters shall be the dry-media or viscous adhesive type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding 1.5 m/s (300 fpm), with initial resistance of 32 Pa (0.13 inches water gauge). Average efficiency shall be not less than 80 percent when tested according to ASHRAE 52.2.

2.8.2 Sectional Cleanable Filters

Cleanable filters shall be 50 mm (2 inches) thick, unless otherwise indicated. Viscous adhesive shall be provided in 20 liter (5 gallon) containers in sufficient quantity for 12 cleaning operations and not less than 1 liter (1 quart) for each filter section. One washing and charging tank shall be provided foe every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and double drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position.

2.9 FUEL-OIL SYSTEMS

Fuel oil systems shall conform to Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.10 FUEL-GAS SUPPLY SYSTEM

Fuel-gas supply system shall be as specified in Section 23 11 25 FACILITY GAS PIPING and Section 33 51 15 NATURAL-GAS/LIQUID PETROLEUM GAS DISTRIBUTION.

2.11 DUCTWORK COMPONENTS

2.11.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA 1966 unless otherwise specified. Elbows shall be radius type with a centerline radius of 1-1/2 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa (1/2, 1, and 2 inch w.g.) ductwork shall meet the requirements of Seal Class C. Class 750 through 2500 Pa (3 through 10 inch) shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm (2 inch) band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable.

2.11.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated. Factory-fabricated reducing fittings for systems using round duct sections when formed to the shape of the ASME short flow nozzle, need not comply with the maximum angles specified.

2.11.1.2 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runouts length shall be as shown on the drawings, but shall not exceed 3 m (10 feet). Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.11.1.3 General Service Duct Connectors

A flexible duct connector approximately 150 mm (6 inches) in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with NFPA 701 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.11.2 Fibrous Glass Ductwork

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including components, shall be fabricated in accordance with NAIMA AH116 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Fibrous glass ductwork shall have the thermal equivalent of the insulation specified for metal ductwork in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. Duct wall penetrations, traverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH116, where applicable, except that pressure sensitive tape shall not be used as a sealant. All items necessary for a complete installation shall be provided as specified for sheet metal duct systems. Fibrous glass ducts will not be used in ductwork systems for medical facilities or in clean rooms with requirements equal to or exceeding Class 100.

2.11.3 Ductwork Accessories

2.11.3.1 Duct Access Doors

Access doors shall be provided in ductwork where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA 1966. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 by 450 mm (15 by 18 inches), unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 by 600 mm (24 by 24 inches) or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

2.11.3.2 Fire Dampers

Fire dampers shall be 1-1/2 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specified application, and shall be installed in accordance with their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resistance. Fire dampers shall be curtain type with damper blades in or out of the air stream or single or multi-blade typeas indicated in contract drawings. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition of floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA 1819 and in manufacturer's instructions for fire dampers shall be followed.

2.11.3.3 Splitters and Manual Balancing Dampers

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portion of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 5 mm (3/16 inch) rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 200 mm (8 inches). Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm (12 inches). Access doors or panels shall be provided for all concealed damper operators and locking setscrew. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

2.11.3.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein . Fixed air deflectors, also called turning vanes, shall be provided in all 90 degree elbows.

2.11.4 Duct Sleeves, Framed Prepared Openings, Closure Collars

2.11.4.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm (15 inches) in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm (15 inches) in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor is responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A53/A53M, Schedule 20 shall be used. Sleeve shall provide 25 mm (1 inch) clearance between the duct and the sleeve or 25 mm (1 inch) clearance between the insulation and the sleeve for insulated ducts.

2.11.4.2 Framed Prepared Opening

Openings shall have 25 mm (1 inch) clearance between the duct and the opening or 25 mm (1 inch) clearance between the insulation and the opening for insulated ducts.

2.11.4.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm (4 inches) wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm (15 inches) in diameter or less shall be fabricated from 1.0 mm (20 gauge) galvanized steel. Collars for round duct larger than 375 mm (15 inches) and all square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) galvanized steel. Collars shall be installed with fasteners on maximum 150 mm (6 inch) centers, except that not less than 4 fasteners shall be used.

2.11.5 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m (7 feet) above the floor, they shall be protected by a grille or screen in accordance with NFPA 90A.

2.11.5.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with antismudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Electrical Constructn for the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.11.5.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm (6 inches) below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm (6 inches) above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

2.11.6 Louvers

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 07 60 00 FLASHING AND SHEET METAL.

2.12 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A123/A123M or ASTM A653/A653M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphated and coated with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint in accordance with ASTM D520, Type I.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work and working conditions, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

The warm air heating installation shall conform to the requirements contained in NFPA 90A or NFPA 90B, as applicable. Combustion air supply and ventilation shall be in accordance with NFPA 31 or NFPA 54, as applicable. Submit drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Show on the drawings complete equipment wiring diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit; proposed layout and anchorage of equipment and appurtenance and equipment relationship to other parts of the work including clearances required for maintenance and operation.

3.2.1 Furnaces

Foundations, settings, or suspensions for mounting equipment and accessories including supports, vibration isolators, stands, guides, anchors, clamps, and brackets shall be provided. Foundations and suspension for equipment shall conform to the recommendations of the manufacturer, unless otherwise indicated on drawings. Anchor bolts and sleeves shall be set accurately using properly constructed templates. Anchor bolts, when embedded in concrete, shall be provided with welded-on plates on the head end and guarded against damage until equipment is installed. Equipment bases shall be leveled, using jacks or steel wedges, and when resting on concrete shall be neatly grouted-in with a nonshrinking type of grout. Equipment shall be located as indicated and in such a manner that working space is available for all necessary servicing, such as shaft removal, replacing, or adjusting drives, motors, or shaft seals, air filters, access to automatic controls, humidifiers, and lubrication. Electrical isolation shall be provided between dissimilar metals for the purpose of minimizing galvanic corrosion. The interior of cabinets or casings shall be cleaned before completion of installation. The furnace shall be connected to the vent or chimney with the specified connectors, draft regulators, draft loads, and induced draft fans, as applicable, in accordance with NFPA 211.

3.2.2 Automatic Vent Dampers

Automatic vent dampers shall be installed in accordance with ANSI Z21.66/CGA 6.14.

3.2.3 Humidifiers

Humidifiers shall be installed in accordance with manufacturer's instructions and in an arrangement that will permit access and ease of maintenance. Piping, draining, manual shut-off valve, and solenoid valves when required for type of humidifier furnished shall be provided. Drain lines shall be provided for humidifiers and shall be piped to drains shown. Humidifiers installed in a bypass arrangement shall be provided with an integral damper that can be conveniently operated to regulate or shut off flow through the humidifier. To permit humidifier operation, a manual ON-OFF switch shall be provided near the humidifier. The ON-OFF switch may be integral with the humidifier. When humidifier is installed in glass fiber ductwork, ductwork shall be adequately reinforced to support the humidifier.

3.2.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and so located that the concealed items may be serviced and maintained or completely removed for replacement. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.2.5 Flexible Connectors

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

3.2.6 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07 84 00 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07 92 00 JOINT SEALANTS.

3.2.7 Metal Ductwork

Installation shall be in accordance with SMACNA 1966 unless otherwise indicated. Duct supports for sheet metal ductwork shall be in accordance with SMACNA 1966, unless otherwise specified. Friction beam clamps indicated in SMACNA 1966 shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor form puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided. Where threaded rods are used, they not be formed or bent.

3.2.8 Fibrous glass Ductwork

Installation shall be in accordance with the manufacturer's written recommendations unless otherwise required in NAIMA AH116. Duct supports for fibrous glass ductwork shall conform to NAIMA AH116. In those cases not covered in NAIMA AH116, the written recommendation of the fibrous duct manufacturer shall be followed.

3.2.9 Air Filters

Air filters shall be installed in heater casings or in return air ducts at furnaces or in return air grilles. Fans or blowers shall not be operated until filters are installed. After completion of tests and before the building is accepted by the Government, furnish a new second set of replaceable filters, where utilized, or clean the permanent type filters.

3.2.10 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection shall remain in place until system is ready for startup.

3.2.11 Insulation

Thickness and application of insulation materials for ductwork and equipment shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.12 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

3.2.13 Fuel-Oil System

Fuel oil systems shall be installed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.3 FIELD PAINTING

Finish painting of items only primed at the factory or surfaces not specifically noted, otherwise are specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 CLEANING

Ducts, plenums, and casings shall be thoroughly cleaned of all debris and blown free of all small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. All equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.5 FIELD TRAINING

a. Conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit proposed schedule for field training, at least 2 weeks prior to the start of related training. Training shall be provided for a period of 8 hours of normal working time shall start after the system is functionally complete but prior to the performance tests.

b. The field instruction shall cover all of the items contained in the approved operating and maintenance manuals. Submit one hard copy & one digital copy (.pdf - text searchable) of the manuals listing step-by-step procedures required for system startup, operation, shutdown and routine maintenance, at least 2 weeks prior to field training. Include in the manuals the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

c. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

3.6 TESTS

Upon completion and prior to acceptance of the installation, furnish all equipment, instruments, materials, labor, and supervision required for the tests as specified. Submit proposed test procedures for ductwork leak and performance tests, at least 2 weeks prior to the start of related testing.

a. Obtain necessary natural gas, water and electricity as specified in the SPECIAL CONTRACT REQUIREMENTS Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Provide necessary quantities of propane gas fuel oil when propane gas or fuel oil is require for testing.

b. Defects disclosed by the tests shall be rectified. Tests shall be made under the direction and subject to the approval of the Contracting Officer. All indicating instruments shall be read at 1/2-hour intervals unless otherwise directed by the Contracting Officer. Submit proposed System Diagrams, at least 2 weeks prior to start of related testing.

c. System diagrams that show the layout of equipment and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

d. Submit test reports for the ductwork leak test and the performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

3.6.1 Ductwork Leak Test

Ductwork leak test shall be performed for the entire air distribution system, including fans, coils, filters etc. designated as static pressure Class 750 Pa (3 inch w.g.) through Class 2500 Pa (10 in w.g.). Test procedure, apparatus, and report shall conform to SMACNA 1972 CD. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

3.6.2 Testing, Adjusting, and Balancing

Testing, adjusting, and balancing shall be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.6.3 Performance Tests

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be conducted by an experienced engineer. Tests shall cover a period of not less than one days for each system and shall demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the humidity in a shaded and weather protected area.

-- End of Section --

SECTION 23 82 02.00 10

UNITARY HEATING AND COOLING EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 320	(1998) Water-Source Heat Pumps
AHRI 325	(1998) Ground Water-Source Heat Pumps
AHRI 350	(2008) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 490 I-P	(2011) Performance Rating of Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers
AHRI 540	(2004) Performance Rating Of Positive Displacement Refrigerant Compressors And Compressor Units
AHRI 700	(2014; Appendix C & D 2014) Specifications for Fluorocarbon Refrigerants
ANSI/AHRI 210/240	(2008; Add 1 2011; Add 2 2012) Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
ANSI/AHRI 270	(2008) Sound Rating of Outdoor Unitary Equipment
ANSI/AHRI 340/360	(2007) Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
ANSI/AHRI 370	(2011) Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 495	(2005) Performance Rating of Refrigerant

	Liquid Receivers
ANSI/AHRI/CSA 310/380	(2004) Standard for Packaged Terminal Air-Conditioners and Heat Pumps

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 127	(2012) Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners
ASHRAE 52.2	(2012; Errata 2013; INT 1 2014) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 64	(2011) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS (AHAM)

AHAM RAC-1	(1982; R2008) Directory of Certified Room Air Conditioners

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1071	(2012) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2014) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2014) Motors and Generators
NEMA MG 2	(2014) Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2015) National Fuel Gas Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 1995	(2011) Heating and Cooling Equipment
UL 207	(2009; Reprint Jun 2014) Refrigerant-Containing Components and Accessories, Nonelectrical
UL 484	(2014; Reprint Mar 2014) Standard for Room Air Conditioners
UL 586	(2009; Reprint Sep 2014) Standard for High-Efficiency Particulate, Air Filter Units
UL 900	(2004; Reprint Feb 2012) Standard for Air Filter Units

1.2 SYSTEM DESCRIPTION

Provide electrical equipment, motors, motor efficiencies, and wiring which are in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 W (1 horsepower) and above with open, drip-proof, totally enclosed, or explosion proof fan cooled enclosures, shall be the premium efficiency type in accordance with NEMA MG 1. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings

SD-03 Product Data

Materials and Equipment
Spare Parts
Posted Instructions
Verification of Dimensions
Coil Corrosion Protection
System Performance Tests
Demonstrations

SD-06 Test Reports

Refrigerant Tests, Charging, and Start-Up
System Performance Tests

SD-07 Certificates

Materials and Equipment
Service Organization

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Submit drawings provided in adequate detail to demonstrate compliance with contract requirements. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Submit drawings consisting of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

f. Automatic temperature control diagrams and control sequences.

g. Installation details which include the amount of factory set superheat and corresponding refrigerant pressure/temperature.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 2 months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide Materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. Submit manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements.

a. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations. Data shall be submitted for each specified component.

b. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

c. Where the system, components, or equipment are specified to comply with requirements of AHRI, ASHRAE, ASME, or UL, proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted.

d. When performance requirements of this project's drawings and specifications vary from standard AHRI rating conditions, computer printouts, catalog, or other application data certified by AHRI or a nationally recognized laboratory as described above shall be included. If AHRI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

e. Products shall be supported by a service organization. Submit a certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract. System components shall be environmentally suitable for the indicated locations.

2.1.2 Nameplates

Major equipment including compressors, condensers, receivers, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.1.3 Safety Devices

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

2.2 UNITARY EQUIPMENT, ROOM UNIT

2.2.1 Window or Through-the-Wall Mounted Unit

Unit shall be a window or through-the-wall mounted, appliance grade, factory assembled air-conditioner unit. Unit shall be in accordance with AHAM RAC-1 and UL 484. Units shall include a self-contained, precharged, slide-in and removable chassis-mounted, air-cooled refrigeration system. Cooling section shall be equipped with a filter-drier on the suction line. Fan and condenser motors shall have totally enclosed enclosures, unless otherwise indicated.

2.2.2 Packaged Terminal Unit

Unit shall be a through-the-wall mounted, heavy-duty commercial grade, factory assembled and precharged air-conditioner or heat pump unit, as indicated. Unit shall be in accordance with ANSI/AHRI/CSA 310/380 and UL 1995. Units shall be removable from inside the building for servicing without removing the outside cabinet. Unit shall have a noise rating in accordance with AHRI 350. Heat pump units shall contain a reversing valve to change unit to heating cycle. An outdoor coil temperature sensor shall be provided to guard against coil freeze-up by either switching to supplemental heat only, or by cycling the compressor to defrost the coil.

2.2.3 Compressor

Compressor shall be hermetically sealed reciprocating, rotary, or scroll type. Compressor shall be fitted with permanent split capacitor motor, overload protection, and vibration isolators. Compressor shall be protected against high discharge pressure, loss of charge, low voltage, and short cycling.

2.2.4 Air-To-Refrigerant Coils

Evaporator and condenser coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. A condensate removal system shall be provided.

2.2.5 Fans

Indoor and outdoor fans shall be the centrifugal, direct driven type. Fans shall be statically and dynamically balanced. Outdoor fan shall be designed so that condensate will evaporate without drip, splash, or spray on building exterior. Indoor fan shall be provided with a minimum two-speed motor with built-in overload protection. Fan motors shall be the inherently protected, permanent split-capacitor type.

2.2.6 Air Filters

Filters shall be of the sectional or panel cleanable type and be capable of filtering the entire air supply.

2.2.7 Primary/Supplemental Heat

Primary or supplemental heat shall be provided as specified in paragraph "Unitary Equipment Components".

2.2.8 Cabinet Construction

Cabinet shall be free of visible fasteners, sharp protuberances and edges. Enclosure sheet metal shall be a minimum of 1.2 mm (18 gauge) steel with a protective coating. Face panels shall be removable and shall provide full access to unit appurtenances. Access to controls shall be without removal of the face panel. Conditioned air shall discharge through adjustable louvers. Cabinet shall be thermally and acoustically insulated with materials which conform to NFPA 90A. Units shall be furnished with a field-wired or prewired sub base. Sub base shall have leveling screws without provisions for remote unit control, unless otherwise indicated. Sub base shall be of 1.3 mm (18 gauge) galvanized steel construction with a protective coating to match that of the room cabinet. Paint and finishes shall comply with the requirements specified in paragraph FACTORY COATING.

2.2.9 Wall Sleeve

Louver shall be storm-proof type, constructed of anodized, stamped or extruded aluminum. Sleeve shall be a water and airtight completely insulated assembly, unless otherwise indicated, with weather-resistant protective coating.

2.2.10 Duct Package

Duct extension shall consist of 1.3 mm (18 gauge) minimum galvanized steel plenum extender with all necessary internal dampers and baffles to divert the supply air as indicated. Duct extension shall be painted with a protective coating that matches room cabinet.

2.2.11 Unit Controls

Controls shall include an on-off switch, high and low selector switch for both the heating and cooling mode, multiple speed fan for cooling and heating mode, room air fan switch, outside air damper control, and an adjustable cooling and heating thermostat. Function and temperature controls shall be integral to unitunless otherwise indicated.

2.3 UNITARY EQUIPMENT, PACKAGE SYSTEM

Unit shall be an air-cooled, water-cooled, or evaporatively-cooled factory assembled, weatherproof or indoor packaged unit as indicated. Unit shall be the air-conditioning or heat pump type, as indicated conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit shall be rated in accordance with ANSI/AHRI 210/240, ANSI/AHRI 340/360, AHRI 320 or AHRI 325. Unit shall be provided with equipment as specified in paragraph "Unitary Equipment Components". Evaporator or supply fans shall be double-width, double inlet, forward curved, backward inclined, or airfoil blade, centrifugal scroll type. Motors shall have totally enclosed enclosures, unless otherwise indicated. Condenser fans shall be manufacturer's standard for the unit specified and may be either propeller or centrifugal scroll type. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged with refrigerant and oil in accordance with manufacturer's recommendations. Outdoor unit shall produce a maximum AHRI sound rating of 8.6 bels in accordance with ANSI/AHRI 270 or ANSI/AHRI 370. Interior water source piping shall be insulated as a "cold pipe" described in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Water-cooled unit shall be fitted with a strainer protected solenoid shut-off valve. The valve shall be a fully automatic, self-contained temperature regulating valve with integral thermometer.

2.3.1 Air-to-Refrigerant Coils

Air-to-refrigerant coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.3.2 Water-to-Refrigerant Coils

Coils shall be of the tube-in-tube, shell-and-coil, shell-and-tube, or concentric tube type and be provided as an integral part of the packaged unit. Water-wetted metals shall be copper or copper-nickel, except that heads may be ferrous metal in systems with chemically treated recirculating water. Coils shall be rated for not less than 2758 kPa (400 psi) refrigerant side and 862 kPa (125 psi) water side pressure service at operating temperatures. Coils shall be supplied with water as indicated. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) nor more than 3 m/s (10 fps) with a fouling factor of 0.0005.

2.3.3 Evaporatively-Cooled Section

The evaporative section shall be a packaged component of the unitary equipment. Unit shall be the counter-flow blow-through design, with single-side air entry. Unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 16-gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153/A153M and ASTM A123/A123M, as applicable and a minimum coating thickness of 0.76 kg/square meter (2.5 ounces/square foot) of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit.

2.3.3.1 Pan Section

The pan shall be watertight and be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.3.3.2 Fan Section

Fan shall be the centrifugal or propeller type in accordance with paragraph "Fans". Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have totally enclosed enclosure, unless otherwise indicated, and be suitable for the indicated service. The unit design shall prevent water from entering into the fan section.

2.3.3.3 Condensing Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter without fins, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system.

2.3.3.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and be arranged for easy access.

2.3.3.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the unit or remotely on a separate mounting pad. Pumps shall have cast-iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have totally enclosed enclosures, unless otherwise indicated. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.3.3.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.3.3.7 Evaporator Controls

Unit shall be provided with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers shall modulate to reduce the airflow across the condensing coil. Controls shall include a proportional acting pressure controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycling of a fan motor on and off shall be in accordance with the manufacturer.

2.3.4 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 35 kW (10 tons) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors shall operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Compressors shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, thermal overloads, lubrication pump, high and low pressure safety cutoffs and protection against short cycling.

2.3.5 Refrigeration Circuit

Refrigerant containing components shall comply with ANSI/ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve.

2.3.6 Unit Controls

Unit shall be internally prewired with a 24 VDC or 120 VAC control circuit powered by an internal transformer, as indicated. Terminal blocks shall be provided for power wiring and external control wiring. Unit shall have cutoffs for high and low pressure, and low oil pressure for compressors with positive displacement oil pumps, supply fan failure and safety interlocks on all service panels. Head pressure controls shall sustain unit operation with ambient temperature of -29 degrees C (-20 degrees F). Adjustable-cycle timers shall prevent short-cycling. Multiple compressors shall be staged by means of a time delay. Unit shall be internally protected by fuses or a circuit breaker in accordance with UL 1995. Low cost cooling shall be made possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

2.4 UNITARY EQUIPMENT, SPLIT SYSTEM

Unit shall be an air-cooled, water-cooled, or evaporatively-cooled, split system which employs a remote condenser or condensing unit, a separate indoor unit, and interconnecting refrigerant piping, as indicated. Unit shall be the air-conditioning or heat pump type conforming to applicable Underwriters Laboratories (UL) standards including UL 1995, as indicated. Unit shall be rated in accordance with ANSI/AHRI 210/240, ANSI/AHRI 340/360, AHRI 320, or AHRI 325. Unit shall be provided with necessary fans, air filters, coil frost protection, liquid receiver, internal dampers, mixing boxes, supplemental heat, and cabinet construction as specified in paragraph "Unitary Equipment Components". The remote unit shall be as specified in paragraph REMOTE CONDENSER OR CONDENSING UNIT. Evaporator or supply fans shall be double-width, double inlet, forward curved, backward inclined, or airfoil blade, centrifugal scroll type. Condenser or outdoor fans shall be the manufacturer's standard for the unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors shall have totally enclosed enclosures, unless otherwise indicated.

2.4.1 Air-to-Refrigerant Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.4.2 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 35 kW (10 tons) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, thermal overloads, lubrication pump, high and low pressure safety cutoffs and protection against short cycling.

2.4.3 Refrigeration Circuit

Refrigerant-containing components shall comply with ANSI/ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. A refrigerant suction line thermostatic and water flow switch control shall be provided to prevent freeze-up in event of loss of water flow during heating cycle.

2.4.4 Unit Controls

Unit shall be internally prewired with a 24 VDC or 120 VAC control circuit powered by an internal transformer, as indicated. Terminal blocks shall be provided for power wiring and external control wiring. Unit shall have cutoffs for high and low pressure, and low oil pressure for compressors with positive displacement oil pumps, supply fan failure, and safety interlocks on all service panels. Head pressure controls shall sustain unit operation with ambient temperature of -29 degrees C (-20 degrees F). Adjustable-cycle timers shall prevent short-cycling. Multiple compressors shall be staged by means of a time delay. Unit shall be internally protected by fuses or a circuit breaker in accordance with UL 1995. Low cost cooling shall be made possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

2.5 REMOTE CONDENSER OR CONDENSING UNIT

Units with capacities less than 39.5 kW (135,000 Btuh) shall produce a maximum AHRI sound rating of 8.6 bels when rated in accordance with ANSI/AHRI 270. Units with capacities 39.5 kW (135,000 Btuh) or greater shall produce a maximum AHRI sound rating of 8.8 bels when rated in accordance with ANSI/AHRI 370. Each remote condenser coil shall be fitted with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature shall not exceed 49 degrees C (120 degrees F) at 40 degrees C (95 degrees F) ambient. Unit shall be provided with low ambient condenser controls to ensure proper operation in an ambient temperature of -29 degrees C (-20 degrees F). Fan and cabinet construction shall be provided as specified in paragraph "Unitary Equipment Components". Fan and condenser motors shall have totally enclosed enclosures, unless otherwise indicated.

2.5.1 Air-Cooled Condenser

Unit shall be rated in accordance with ANSI/AHRI 460 and conform to the requirements of UL 1995. Unit shall be factory fabricated, tested, packaged, and self-contained. Unit shall be complete with casing, propeller or centrifugal type fans, heat rejection coils, connecting piping and wiring, and all necessary appurtenances.

2.5.1.1 Connections

Interconnecting refrigeration piping, electrical power, and control wiring between the condensing unit and the indoor unit shall be provided as required and as indicated. Electrical and refrigeration piping terminal connections between condenser or condensing unit and evaporator units shall be provided.

2.5.1.2 Head Pressure Control and Liquid Subcooling

Low ambient control for multi-circuited units serving more than one evaporator coil shall provide independent condenser pressure controls for each refrigerant circuit. Controls shall be set to produce a minimum of 95 degrees F saturated refrigerant condensing temperature. Unit shall be provided with a liquid subcooling circuit which shall ensure proper liquid refrigerant flow to the expansion device over the specified application range of the condenser. Unit shall be provide with manufacturer's standard or not less than 4 degrees C (8 degrees F) liquid subcooling. Subcooling circuit shall be liquid sealed.

2.5.1.3 Condensing Coil

Coils shall have nonferrous or copper or aluminum tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.5.1.4 Unit Controls

The control system shall be complete with required accessories for regulating condenser pressure by fan cycling, solid-state variable fan speed, modulating condenser coil or fan dampers, flooding the condenser, or a combination of the above. Unit mounted control panels or enclosures shall be constructed in accordance with applicable requirements of NFPA 70 and housed in NEMA ICS 6, Class 1 or 3A enclosures. Controls shall include control transformer, fan motor starters, solid-state speed control, electric heat tracing controls, time delay start-up, overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.5.2 Evaporative Condenser

Each unit shall be the counter-flow blow-through design, with single-side air entry. The unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 1.6 mm (16-gauge) steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153/A153M and ASTM A123/A123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square meter (2.5 ounces/square foot) of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit. Unit shall be rated in accordance with AHRI 490 I-P and tested in accordance with the requirements of ASHRAE 64.

2.5.2.1 Pan Section

The pan shall be watertight and be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.5.2.2 Fan Section

Fan shall be the centrifugal or propeller type in accordance with paragraph "Fans". Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have totally enclosed enclosure, unless otherwise indicated, and be suitable for the indicated service. The condensing unit design shall prevent water from entering into the fan section.

2.5.2.3 Condensing Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter without fins, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged.

2.5.2.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and be arranged for easy access.

2.5.2.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pumps shall have cast-iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have totally enclosed enclosures, unless otherwise indicated. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.5.2.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.5.2.7 Unit Controls

The evaporative condenser unit shall be provided with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers shall modulate to reduce the airflow through the evaporative condenser. Controls shall include a proportional acting pressure controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycling of a fan motor on and off shall be in accordance with the manufacturer.

2.5.3 Compressor

Unit shall be rated in accordance with AHRI 540. Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Units 35 kW (120,000 Btuh) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, lubrication pump, thermal overloads, and high and low pressure safety cutoffs and protection against short cycling.

2.6 AIR-CONDITIONERS FOR ELECTRONIC DATA PROCESSING (EDP) SPACES

Unit shall be an air-cooled or water-cooled, self-contained type air-conditioning unit. Unit shall be a packaged unit with an internal water-cooled condenser or a split-system with a remote condenser or condensing unit, as indicated on contract drawings. Unit shall be designed and constructed for automatic control of space conditions. Unit shall be in accordance with ASHRAE 127 and UL 1995. Unit shall be rated in accordance with ANSI/AHRI 210/240 or ANSI/AHRI 340/360. AHRI certification is not required. The system shall be designed and constructed for maximum reliability and ease of maintenance. Necessary redundancy, access to refrigeration circuits, means of troubleshooting, and malfunction alarms shall be provided. Unit shall be provided with necessary fans, air filters, coil frost protection, liquid receiver, internal dampers, mixing boxes, supplemental heat, and cabinet construction as specified in paragraph "Unitary Equipment Components". Evaporator or supply fans shall be double-width, double inlet, forward curved centrifugal scroll type. Condenser or outdoor fans shall be manufacturer's standard for unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors shall have totally enclosed enclosures, unless otherwise indicated. Remote unit shall be as specified in paragraph REMOTE CONDENSER/CONDENSING UNIT.

2.6.1 Air-to-Refrigerant Coils

Evaporator or evaporator and condenser coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Units shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.6.2 Water-to-Refrigerant Coils

Unit shall be of the tube-in-tube, shell-and-coil, shell-and-tube, or concentric tube type and be provided as an integral part of the self-contained unit. Water-wetted metals shall be copper or copper-nickel, except that heads may be ferrous metal in systems with chemically treated recirculating water. Unit shall be rated for not less than 2758 kPa (400 psi) refrigerant side and 862 kPa (125 psi) water side pressure service at operating temperatures. Unit shall be supplied with water as indicated. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) nor more than 3 m/s (10 fps) with a fouling factor of 0.0005. A separate condenser shall be provided for each compressor circuit. Control shall be set for refrigerant condensing temperature as indicated on contract drawings. Units which use a once-thru water-source shall be fitted with a strainer protected solenoid shut-off valve. The valve shall be a fully automatic, self-contained temperature regulating valve with integral thermometer. Mercury shall not be used in thermometers.

2.6.3 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 26 kW (7.5 tons) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, lubrication pump, thermal overloads, and high and low pressure safety cutoffs and protection against short cycling.

2.6.4 Refrigeration Circuit

Refrigerant-containing components shall comply with ANSI/ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. A refrigerant suction line thermostatic and water flow switch control shall be provided to prevent freeze-up in event of loss of water flow during heating cycle.

2.6.5 Unit Controls

A unit's basic functions and space ambient conditions shall be controllable at one station. A temperature and humidity strip-chart recorder, integral or external to the unit, readable to specified control accuracy, shall be provided, complete with cartridge ink and chart supply for 1 year of operation.

2.6.5.1 Externally Accessible Controls

The following controls shall be externally accessible:

a. Start and stop total system functions.

b. Audible alarm silence.

c. Main power disconnect.

2.6.5.2 Status Indicators

The following status indicators shall be externally visible:

a. Power On.

b. System On.

c. Malfunction.

d. Provision for remote alarm status indication.

2.6.5.3 Alarmed Conditions

The following system status conditions shall be both audibly and visually alarmed:

a. Loss of air flow.

b. Dirty filters.

c. Compressor overload or lock-out (compressor high head pressure and low suction pressure).

d. High and low room temperature.

e. High humidity alarm at percent relative humidity indicated on contract drawings.

2.6.5.4 Space Temperature

Space temperature shall be controlled within plus or minus 1 degree C (1.5 degrees F) of the set point over a range of 16 to 32 degrees C (60 to 90 degrees F) with a set point as indicated. Space relative humidity shall be controlled within plus or minus 5 percent of the set point over a range of 20 to 80 percent with a set point as indicated.

2.6.5.5 Safety Controls

Safety controls shall include the following:

a. Fused, unfused or line-break circuit breaker disconnects, as indicated or required.

b. Automatic pump-out or pump-down liquid flooding controls.

c. High refrigerant pressure cutout.

d. Low refrigerant pressure cutout where automatic pump-down is not provided.

e. Accessible hermetic and open compressor low oil pressure cutout.

f. Elapsed time meter for each compressor where load equalization is not incorporated.

g. Lead and lag compressor selector switch, when compatible with system.

2.6.6 Cabinet Construction

Cabinet shall be totally enclosed. Enclosure surfaces shall be pulsation free, with hinged and removable doors and panels for vertical side or front access to unit components. Routine maintenance access to compressor and system control components shall be possible without unit shut-down. Enclosure surfaces shall be thermally and acoustically insulated. Interior baffle and compartment surfaces shall be galvanized steel. Drain pans shall collect all condensate and be steel with external insulation as required. Surface mounting steel pads and vibration isolating pads shall be provided. Enclosure surfaces shall be prepared, primed and finished. Paint and finishes shall comply with the requirements specified in paragraph FACTORY COATING. Cabinets shall be fitted with integral or separable, adjustable and lockable jacks to support the units from the structural slab at the raised-floor elevation.

2.7 EQUIPMENT EFFICIENCY

Unit shall have an efficiency as indicated on the drawings.

2.8 UNITARY EQUIPMENT COMPONENTS

2.8.1 Refrigerant and Oil

Refrigerant shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. Refrigerants shall meet the requirements of AHRI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05. Provide and install a complete charge of refrigerant for the installed system as recommended by the manufacturer. Lubricating oil shall be of a type and grade recommended by the manufacturer for each compressor. Where color leak indicator dye is incorporated, charge shall be in accordance with manufacturer's recommendation.

2.8.2 Fans

Fan wheel shafts shall be supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Unit fans shall be selected to produce the cfm required at the fan total pressure. Motor starters, if applicable, shall be magnetic across-the-line type with a open, drip-proof, totally enclosed, or explosion proof enclosure. Thermal overload protection shall be of the manual or automatic-reset type. Fan wheels or propellers shall be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings shall be of galvanized steel, and both centrifugal and propeller fan casings shall be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, shall be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting shall be recoated with an approved zinc-rich compound. Fan wheels or propellers shall be statically and dynamically balanced. Direct-drive fan motors shall be of the multiple-speed variety. Belt-driven fans shall have adjustable sheaves to provide not less than 20 percent fan-speed adjustment. The sheave size shall be selected so that the fan speed at the approximate midpoint of the sheave adjustment will produce the specified air quantity. Centrifugal scroll-type fans shall be provided with streamlined orifice inlet and V-belt drive. Each drive will be independent of any other drive. Propeller fans shall be direct-drive or V-belt drive type with adjustable or fixed pitch blades. V-belt driven fans shall be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Each drive will be independent of any other drive. Drive bearings shall be protected with water slingers or shields. V-belt drives shall be fitted with guards where exposed to contact by personnel and fixed pitch or adjustable pitch sheaves.

2.8.3 Primary/Supplemental Heating

2.8.3.1 Water Coil

Coil shall conform to the provisions of AHRI 410. Coil shall be fin-and-tube type constructed of seamless copper tubes and aluminum or copper fins mechanically bonded or soldered to tubes. Headers shall be constructed of cast iron, welded steel or copper. Coil shall be constructed to float within the casing to allow free expansion and contraction of tubing. Casing and tube support sheets shall not be lighter than 1.6 mm (16 gauge) galvanized steel formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Coil shall be circuited for suitable water velocity without excessive pressure drop and properly pitched for drainage where required or indicated. Each coil shall be tested at the factory under water at not less than 2000 kPa (300 psi) air pressure, tested hydrostatically after assembly of the unit and proved tight under a gauge pressure of 1400 kPa (200 psi). Coil shall be suitable for use with water up to 120 degrees C (250 degrees F). Coil shall allow complete coil drainage with a pitch of not less than 10 mm/meter (1/8 inch/foot) slope to drain.

2.8.3.2 Steam Coil

Coil shall conform to the provisions of AHRI 410. Coil shall be constructed of cast semi-steel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered. Tubes shall be rolled and bushed and brazed or welded into headers. Coil casings and tube support sheets, with collars of ample width, shall be not lighter than 1.6 mm (16 gauge) galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. The fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure-steam service. Coils shall be factory pressure tested and capable of withstanding 1700 kPa (250 psi) hydrostatic test pressure or 1700 kPa (250 psi) air pressure, and be for 700 kPa 100 psi steam working pressure. Preheat coils shall be steam-distributing tube type. Condensing tubes shall be not less than 15 mm (5/8 inch) outside diameter. Distribution tubes shall be not less than 10 mm (3/8 inch) outside diameter, and be equipped with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentrically inside of condenser tubes and be held securely in alignment. The maximum length of a single coil shall be limited to 120 times the diameter of the outside tube. Other heating coils shall be minimum 13 mm (1/2 inch) outside diameter single-tube type. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coil shall allow complete coil drainage with a pitch of not less than 10 mm/meter (1/8 inch/foot) slope to drain.

2.8.3.3 Electric Heating Coil

Coil shall be an electric duct heater in accordance with UL 1995 and NFPA 70. Coil shall be duct- or unit-mounted. Coil shall be of the nickel chromium resistor, single stage, strip or stainless steel, fin tubular type. Coil shall be provided with a built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Coil casing and support brackets shall be of galvanized steel or aluminum. Coil shall be mounted to eliminate noise from expansion and contraction and be completely accessible for service.

2.8.3.4 Gas-Fired Heating Section

Gas-fired heat exchanger shall be constructed of aluminized steel, ceramic coated cold-rolled steel or stainless steel suitable for natural gas fuel supply. Burner shall have direct spark or hot surface ignition. Valve shall include a pressure regulator. Combustion air shall be supplied with a centrifugal combustion air blower. Safety controls shall include a flame sensor and air pressure switch. Heater section shall be mounted to eliminate noise from expansion and contraction and shall be completely accessible for service. Gas equipment shall bear the AGA label for the type of service involved. Burner shall be in accordance with NFPA 54.

2.8.4 Air Filters

Air filters shall be listed in accordance with requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test Method shall be as listed under the label service and shall meet the requirements of UL 586.

2.8.4.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm (2 inch) depth sectional type of the size indicated and shall have an average efficiency of 25 to 30 percent when tested in accordance with ASHRAE 52.2. Initial resistance at 2.54 m/s (500 feet/minute) will not exceed 90 Pa (0.36 inches water gauge). Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media shall be attached to a moisture resistant fiberboard frame. Four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

2.8.4.2 Replaceable Media Filters

Replaceable media filters shall be the dry-media or viscous adhesive type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding 1.52 m/s (300 feet/minute), with initial resistance of 32 Pa)0.13 inches water gauge). Average efficiency shall be not less than 80 percent when tested in accordance with ASHRAE 52.2.

2.8.4.3 Sectional Cleanable Filters

Cleanable filters shall be 25 or 50 mm (1 or 2 inches) thick. Viscous adhesive shall be provided in 18.9 L (5 gallon) containers in sufficient quantity for 12 cleaning operations and not less than 1 L (one quart) for each filter section. One washing and charging tank shall be provided for every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and single or double drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position.

2.8.5 Coil Frost Protection

Each circuit shall be provided with a coil frost protection system which is a manufacturer's standard. The coil frost protection system shall use a temperature sensor in the suction line of the compressor to shut the compressor off when coil frosting occurs. Timers shall be used to prevent the compressor from rapid cycling.

2.8.6 Pressure Vessels

Pressure vessels shall conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, pressure components shall be tested at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces shall be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed.

2.8.6.1 Hot Gas Muffler

Unit shall be selected by the manufacturer for maximum noise attenuation. Units rated for 100 kW (30 tons) capacity and under may be field tunable type.

2.8.6.2 Liquid Receiver

A liquid receiver shall be provided when a system's condenser or compressor does not contain a refrigerant storage capacity of at least 20 percent in excess of a fully charged system. Receiver shall be designed, filled, and rated in accordance with the recommendations of ANSI/AHRI 495, except as modified herein. Receiver shall be fitted to include an inlet connection; an outlet drop pipe with oil seal and oil drain where necessary; two bull's-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves; thermal well for thermostat; float switch column; external float switches; and purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver shall be provided with a relief valve of capacity and setting in accordance with ANSI/ASHRAE 15 & 34.

2.8.6.3 Oil Separator

Separator shall be the high efficiency type and be provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator shall not exceed 70 kPa (10 psi) during the removal of hot gas entrained oil. Connections to compressor shall be as recommended by the compressor manufacturer. Separator shall be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass, filter for removal of all particulate sized 10 microns and larger, thermometer and low temperature thermostat fitted to thermal well, immersion heater, external float valve fitted with three-valve bypass, and strainer.

2.8.6.4 Oil Reservoir

Reservoir capacity shall equal one charge of all connected compressors. Reservoir shall be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header shall be provided with a 35 kPa (5 psi) pressure differential relief valve. Reservoir shall be provided with the manufacturer's standard filter on the oil return line to the oil level regulators.

2.8.7 Internal Dampers

Dampers shall be parallel blade type with renewable blade seals and be integral to the unitary unit. Damper provisions shall be provided for each outside air intake, exhaust, economizer, and mixing boxes. Dampers shall have manual or automatic modulation, as indicated, and operate as specified.

2.8.8 Mixing Boxes

Mixing boxes shall match the base unit in physical size and shall include equally-sized flanged openings, each capable of full air flow. Arrangement shall be as indicated.

2.8.9 Cabinet Construction

Casings for the specified unitary equipment shall be constructed of galvanized steel or aluminum sheet metal and galvanized or aluminum structural members. Minimum thickness of single wall exterior surfaces shall be 1.3 mm (18 gauge) galvanized steel or 1.8 mm (0.071 inch) thick aluminum on units with a capacity above 70 kW (20 tons) and 1.0 mm (20 gauge) galvanized steel or 1.6 mm (0.064 inch) thick aluminum on units with a capacity less than 70 kW (20 tons). Casing shall be fitted with lifting provisions, access panels or doors, fan vibration isolators, electrical control panel, corrosion-resistant components, structural support members, insulated condensate drip pan and drain, and internal insulation in the cold section of the casing. Where double-wall insulated construction is proposed, minimum exterior galvanized sheet metal thickness shall be 1.0 mm (20 gauge). Provisions to permit replacement of major unit components shall be incorporated. Penetrations of cabinet surfaces, including the floor, shall be sealed. Unit shall be fitted with a drain pan which extends under all areas where water may accumulate. Drain pan shall be fabricated from Type 300 stainless steel, galvanized steel with protective coating as required, or an approved plastic material. Pan insulation shall be water impervious. Extent and effectiveness of the insulation of unit air containment surfaces shall prevent, within limits of the specified insulation, heat transfer between the unit exterior and ambient air, heat transfer between the two conditioned air streams, and condensation on surfaces. Insulation shall conform to ASTM C1071. Paint and finishes shall comply with the requirements specified in paragraph FACTORY COATING.

2.8.9.1 Indoor Cabinet

Indoor cabinets shall be suitable for the specified indoor service and enclose all unit components.

2.8.9.2 Outdoor Cabinet

Outdoor cabinets shall be suitable for outdoor service with a weathertight, insulated and corrosion-protected structure. Cabinets constructed exclusively for indoor service which have been modified for outdoor service are not acceptable.

2.9 ACCESSORIES

2.9.1 Dry-Cooler, Glycol Solution

Unit shall be factory fabricated and tested, packaged, self-contained, complete with casing, propeller or centrifugal type fans, heat rejection coils, appurtenances, and intercomponent piping and wiring. Unit shall be certified by the manufacturer or an independent test laboratory that the unit's ratings meet AHRI 410 the indicated conditions. Unit shall be designed for outdoor or indoor installation, as indicated, and comply with the requirements of UL 1995. Unit shall compatible with the solution specified in paragraph "Glycol Solution". Unit shall be fitted with recirculating pump, expansion tank, Type L copper intercomponent piping, system accessories and controls. Factory assembled piping shall be Type L copper. Cabinet construction shall be in accordance with paragraph "Unitary Equipment Components".

2.9.1.1 Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes, unless otherwise indicated. Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.9.1.2 Fan Section

Fan shall be the centrifugal or propeller type in accordance with paragraph "Fans". Motors shall have totally enclosed enclosures, unless otherwise indicated, and be suitable for the indicated service.

2.9.1.3 Pump

Pump and controls shall be mounted within a lockable sheet metal enclosure supported from dry cooler structure. Pump shall be of the end-suction type with an totally enclosed motor, unless otherwise indicated. Pump construction shall be as specified in paragraph "Pumps". Seals shall be mechanical type suitable for ethylene glycol solution up to a 60 percent concentration of glycol, and be rated for 82 degrees C (180 degrees F) service.

2.9.1.4 Controls

The control system shall be complete with all required accessories for regulating glycol temperature by fan cycling, solid-state variable fan speed, or modulating glycol 3-way mixing valve or modulating fan dampers, as indicated. Unit-mounted control panels or enclosures shall be constructed in accordance with applicable requirements of NFPA 70 and housed in NEMA ICS 6, Class 1 or 3A enclosures. Controls shall include a control transformer, fan motor starters, solid-state speed control, pump motor starters, electric heat tracing controls, time delay start-up, overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.9.2 Humidifier

2.9.2.1 Steam Spray Type

Steam spray humidifiers shall inject steam directly into the surrounding air or air stream. Single grid humidifiers shall consist of a single copper distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condenser traps shall be field-installed. Enclosed grid shall be housed in a copper enclosure with a built-in condensate drain connection. Exposed grid shall be wick wrapped. Package type steam spray humidifiers shall be equipped to trap out and to evaporate condensate and to supply dry steam to a single distribution grid. Grid shall be steam jacketed and condensate drained. Unit shall trap excess condensate to return system. Package type steam spray humidifiers shall have modulating electric, electronic, or pneumatic steam control valve, as indicated. Steam spray humidifiers shall be rated for humidifying capacity in pounds of steam per hour and at steam pressure as indicated.

2.9.2.2 Steam-Diffuser Type

Diffuser units shall be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. Materials shall be noncorrosive materials or Type 300 stainless steel, as indicated.

2.9.3 Purge System

Refrigeration systems which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge systems shall automatically remove air, water vapor, and non-condensable gases from the system's refrigerant. Purge systems shall condense, separate, and return all refrigerant back to the system. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into the system.

2.9.4 Refrigerant Leak Detector

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include single or multiple sampling points installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation system as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be compatible with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.9.5 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC VIII D1 and ANSI/ASHRAE 15 & 34. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.9.6 Refrigerant Signs

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 13 mm (0.5 inches) in height.

2.9.6.1 Installation Identification

Each new refrigeration system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.9.6.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg (110 l)b of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow, the ventilation system, and the refrigerant compressor.

b. Pressure limiting device(s).

2.9.7 Heat Recovery Devices

2.9.7.1 Hot Air Reclaim

Unit shall be a heat recovery, factory-fabricated, draw-through, central station type air conditioner in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.9.7.2 Hot Water Reclaim

Unit shall be a double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit shall be constructed and refrigerant pressure/temperature rated in accordance with ANSI/ASHRAE 15 & 34. Heat exchanger coil shall consist of an external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet shall be fabricated of zinc-protected steel and be internally insulated in coil space. The recovery device shall be provided with a refrigerant compressor head pressure control and a interlocked, potable water circulating pump. Pump and motor assembly shall be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump shall be mounted remotely or integral to the exchanger and be rated for 115 or 208 volt ac power supply.

2.9.8 Gaskets

Gaskets shall conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 370 degrees C (700 degrees F) service.

2.9.9 Bolts and Nuts

Bolts and nuts shall be in accordance with ASTM A307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.9.10 Bird Screen

Screen shall be 1.6 mm (0.063 inch) diameter aluminum wire or 0.79 mm (0.031 inch) diameter stainless steel wire.

2.10 FINISHES

2.10.1 Factory Coating

2.10.1.1 Coil Corrosion Protection

Provide coil with a uniformly applied epoxy electro-deposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating shall be applied at either the coil or coating manufacturer's factory. Coating process shall ensure complete coil encapsulation. Coating shall be capable of withstanding a minimum 1,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.10.1.2 Equipment and Components

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.10.2 Factory Applied Insulation

Refrigeration equipment shall be provided with factory installed insulation on surfaces subject to sweating including the suction line piping. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor in accordance with manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.11 SUPPLEMENTAL COMPONENTS/SERVICES

2.11.1 Condenser Water Piping and Accessories

Condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.11.2 Refrigerant Piping

Refrigerant piping for split-system unitary equipment shall be provided and installed in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.11.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with Section 23 65 00 COOLING TOWERS.

2.11.4 Ductwork

Ductwork shall be provided and installed in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.11.5 Temperature Controls

Temperature controls shall be in accordance with Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform Verification of Dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII D1and ASME BPVC SEC IX, the design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.2.1 Equipment

Refrigeration equipment and the installation thereof shall conform to ANSI/ASHRAE 15 & 34. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm (6 inch) concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators shall limit vibration to 25 percent at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.2.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.2.3 Field Applied Insulation

Field applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.4 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 DEMONSTRATIONS

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

a. Submit a schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

b. Submit the field posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

c. The posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations. One hard copy and one digital copy (.pdf - text searchable) of maintenance manuals listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

d. One hard copy and one digital copy (.pdf - text searchable) of maintenance manuals listing step-by-step procedures required for maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.5 REFRIGERANT TESTS, CHARGING, AND START-UP

Split-system refrigerant piping systems shall be tested and charged as specified in Section 23 23 00 REFRIGERANT PIPING. Packaged refrigerant systems which are factory charged shall be checked for refrigerant and oil capacity to verify proper refrigerant levels in accordance with manufacturer's recommendations. Following charging, packaged systems shall be tested for leaks with a halide torch or an electronic leak detector.

a. The date the tests were performed.
b. A list of equipment used, with calibration certifications.
c. Initial test summaries.
d. Repairs/adjustments performed.
e. Final test results.

3.5.1 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

3.5.2 Contractor's Responsibility

Take steps, at all times during the installation and testing of the refrigeration system, to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.6 SYSTEM PERFORMANCE TESTS

Before each refrigeration system is accepted, conduct tests to demonstrate the general operating characteristics of all equipment by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Submit one hard copy and one digital copy (.pdf - text searchable) of the report. Hard copy shall be provided in bound 216 by 279 mm 8-1/2 by 11 inch booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system.

a. Submit a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications.

b. Make corrections and adjustments, as necessary, tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced.

c. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test.

d. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit one hard copy and one digital copy (.pdf - text searchable) of the report. Hard copy shall be provided in bound 216 by 279 mm 8-1/2 by 11 inch booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. Submit the report including the following information (where values are taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart):

aa. Date and outside weather conditions.

bb. The load on the system based on the following:

(1) The refrigerant used in the system.
(2) Condensing temperature and pressure.
(3) Suction temperature and pressure.
(4) Ambient, condensing and coolant temperatures.
(5) Running current, voltage and proper phase sequence for each phase of all motors.

cc. The actual on-site setting of operating and safety controls.

dd. Thermostatic expansion valve superheat - value as determined by field test.

ee. Subcooling.

ff. High and low refrigerant temperature switch set-points

gg. Low oil pressure switch set-point.

hh. Defrost system timer and thermostat set-points.

ii. Moisture content.

jj. Capacity control set-points.

kk. Field data and adjustments which affect unit performance and energy consumption.

ll. Field adjustments and settings which were not permanently marked as an integral part of a device.

-- End of Section --

SECTION 25 08 10

UTILITY MONITORING AND CONTROL SYSTEM TESTING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2004) Free-Topology Twisted-Pair Channel Specification
CEA-852-C	(2014) Tunneling Component Network Protocols Over Internet Protocol Channels

1.2 DEFINITIONS

1.2.1 Algorithm

A set of well-defined rules or procedures for solving a problem or providing an output from a specific set of inputs.

1.2.2 Analog

A continuously varying signal value (temperature current, velocity, etc.).

1.2.3 Analog to Digital (A/D) Converter

An A/D converter is a circuit or device whose input is information in analog form and whose output is the same information in digital form.

1.2.4 CEA-709.1-D

"Control Network Protocol Specification", Standard communication protocol for networked control systems that provides peer-to-peer communications.

1.2.5 Application Specific Controller

A device that is furnished with a pre-established built in application that is configurable but not re-programmable.

1.2.6 Architecture

Architecture is the general organization and structure of hardware and software.

1.2.7 Binary

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level.

1.2.8 Building Point of Connection (BPOC)

The point of connection between the UMCS network backbone and the building network backbone. The hardware at this location, which performs/provides the connection, is referred to as the BPOC Hardware.

1.2.9 Control Wiring

This includes conduit, wire, and wiring devices to install complete HVAC control systems, including motor control circuits, interlocks, sensors, PE and EP switches, and like devices. This also includes all wiring from node to node, and nodes to all sensors and points defined in the I/O summary shown on drawings or specified herein, and required to execute the sequence of operation. Does not include line voltage power wiring.

1.2.10 Demand

The maximum rate of use of electrical energy averaged over a specific interval of time, usually expressed in kW.

1.2.11 Diagnostic Program

Machine-executable instructions used to detect and isolate system and component malfunctions.

1.2.12 Distributed Control

A system whereby all control processing is decentralized and independent of a central computer. In regards to a LonWorks based system, it also means where the control logic for a single piece of building level control resides in more than one controller (node).

1.2.13 Graphical User Interface (GUI)

Human-machine interfacing allows the operator to manage, command, monitor, and program the system.

1.2.14 Integration

Establishing communication between two or more systems to create a single system.

1.2.15 Interoperable

Two devices are interoperable if installed into the same system and they communicate with each other without the use of another device (such as a gateway).

1.2.16 LonTalk(r)

Open communication protocol developed by the Echelon(r) Corporation.

1.2.17 LONWORKS(r)

The communication technology developed by Echelon(r) Corporation for control systems developed. The technology is based on the CEA-709.1-D protocol and employs interoperable devices along with the capability to openly manage these devices using a network configuration tool.

1.2.18 LONMARK(r) International (LONMARK(r) Interoperability Assoc.)

Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LONWORKS(r) industry.

1.2.19 LonMarked(r)

A device that has been certified for compliance with LonMark(r) standards by the LonMark(r) International.

1.2.20 LONWORKS(r) Application Specific Controller (ASC)

A networked device or node that contains a complete, configurable application that is specific to a particular task.

1.2.21 LONWORKS(r) General Purpose Programmable Controller

A programmable control product, which unlike an ASC, is not installed with a fixed factory-installed application program. The application in the controller is custom software produced by the integrator specifically for the project.

1.2.22 LONWORKS(r) Network Services (LNS)

The database format for addressing nodes and variable bindings node-to-node.

1.2.23 Network

A system of distributed control units that are linked together on a communication bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.

1.2.24 Network Configuration Tool

Software used to create and modify the control network database and configure controllers.

1.2.25 Node ID

A unique 48-bit node identification (ID) tag given to each node by Echelon Corporation.

1.2.26 Node

An intelligent LONWORKS(r) device with a node ID and communicates via CEA-709.1-D and is connected to a CEA-709.1-D network.

1.2.27 Operating System (OS)

Software which controls the execution of computer programs and which provides scheduling, debugging, input/output controls, accounting, compilation, storage assignment, data management, and related services.

1.2.28 Operator Workstation (OWS)

The OWS consists of a high-level processing desktop or laptop computer that provides a graphic user interface to network.

1.2.29 Peripheral

Input/Output (I/O) equipment used to communicate to and from the computer and make hard copies of system outputs and magnetic files.

1.2.30 Router

A device which routes messages destined for a node on another segment subnet or domain of the control network. The device controls message traffic based on node address and priority. Routers may also serve as communication links between power line, twisted pair, fiber, coax, and RF media.

1.2.31 Standard Network Variable Type (SNVT)

A network variable of a standard format type used to define data information transmitted and receive by the individual nodes.

1.2.32 UMCS Network Media

Transmission equipment including cables and interface modules (excluding MODEMs) permitting transmission of digital information.

1.2.33 XIF

"External Interface File" contains the contents of the manufacturer's product documentation.

1.2.34 Gateway

A device that translates from one protocol to another. Gateways are also called Communications Bridges or Protocol Translators.

1.3 SYSTEM DESCRIPTION

a. The purpose of this Specification is to define generic Factory, Performance Verification, and Endurance Test procedures for Utility Monitoring and Control Systems (UMCS) and building level DDC. These tests are to be used to assure that the physical and performance requirements of UMCS and building level DDC are tested, and that the test results are adequately documented. The Government will base certain contractual decisions on the results of these tests.

b. This document covers the factory, performance verification, and endurance test procedures for the Utility Monitoring and Control System (UMCS) and Direct Digital Control for HVAC. It has been written for a host based system where the LONWORKS(r) LNS database resides on the main computer (server) and communicates over the

Ethernet (TCP/IP) connection to the field level controller nodes. The system shall be comprised of the server hardware and software, IP network hardware and software, and building point of connection (BPOC) hardware and software.

c. The contractor who provided building level DDC under Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS is responsible for testing the building level DDC. All control testing and controller tuning required under Section 23 09 23 shall be completed and approved before performing Performance Verification and Endurance Tests under this section.

d. The following UFGS: Section 25 10 10 LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS) and Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS shall be part of the contract documents.

1.3.1 Factory Test

Conduct a factory test at a company site. Perform some of the basic functions of the UMCS and building level DDC, to assure that the performance requirements of the specifications are met.

1.3.2 Performance Verification and Endurance Test

a. Shall be conducted on hardware and software installed at the jobsite to assure that the physical and performance requirements of specifications are met. Tests on network media shall include all contractor furnished media and shall include at least one type of each device installed.

b. Shall be conducted under normal mode operation, unless otherwise indicated in the initial conditions description for each test. System normal mode describes a condition in which the system is performing its assigned tasks in accordance with the contract requirements.

c. Shall utilize the operator workstation (OWS) to issue commands or verify status data.

1.3.3 Test Equipment and Setup

All test equipment calibrations shall be traceable to NIST. The accuracy of the test equipment and overall test method shall be at least twice the maximum accuracy required for the test. For example, if a temperature sensor has an accuracy of +0.5 degree C (+1 degree F) over the executed range, the test instrument used shall have an accuracy of at least +0.25 degree C (+0.5 degree F) or better. Provide all test equipment unless otherwise noted in the contract documents.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Factory Test; G

SD-06 Test Reports

UMCS and Building Level DDC Testing Sequence
Performance Verification Test; G
Endurance Testing

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 UMCS AND BUILDING LEVEL DDC TESTING SEQUENCE

Perform a successful factory test prior to start of installation work, as described in this section. During the installation phase, perform all required field testing requirements on the UMCS and building level DDC as specified in Sections 25 10 10 LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS) and 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS, to verify that systems are functioning and installed in accordance with specifications. Submit field test report prior to start of PVT and endurance testing. After completing all required field testing, perform a successful PVT and endurance test. All tests shall be successfully completed, and test reports received, prior to final acceptance of the UMCS and building level DDC. Perform and document Contractor field test on UMCS and building level DDC.

3.2 COORDINATION

Coordinate the testing schedule with the Government. Coordination shall include controls specified in other sections or divisions which include controls and control devices that are to be part of or interfaced to the UMCS specified in this section.

3.3 PROTECTION

Protect all work and material from damage by the work or workers. The Contractor is liable for any damage caused and responsible for the work and equipment until finally inspected, tested, and accepted. Protect the work against theft, and carefully store material and equipment received onsite that is not immediately installed.

3.4 FACTORY TEST

3.4.1 Factory Test Plan

Prior to the scheduling of the factory tests, provide the Government with a Factory Test Plan for approval, and wait to receive notification of approval of the Test Plan and Procedures before performing the tests. The plan shall include the following, as a minimum:

a. System one-line block diagram of equipment used in the factory test model, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.

b. System hardware description used in the factory test.

c. System software description used in the factory test.

d. Listing of control and status points in the factory test model; plus a table with the following information:

1) Input and output variables.
2) SNVTs for each variable.
3) Expected engineering units for each variable.
4) Node ID.
5) Domain & subnet addressing.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.4.2 Test Procedures

Develop the factory test procedures from the generic test procedures in ATTACHMENT A. The test procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. Edit the generic test procedure for the provided UMCS and building level DDC. Perform a factory test on a model of the UMCS and building level DDC for the Government to verify the system will function to the requirements of the contract documents. The test architecture shall mimic a two building arrangement. There shall be a TCP/IP layer with two Internet Protocol (IP) to Lon routers. Below each of the routers shall be both programmable (GPPC) and application-specific controllers (ASC). One server and one workstation with printers shall be connected to the IP layer. There shall be simulated input devices connected to controllers to enable the creation of changing variables. If, during testing, the system fails a portion of a test, the Government will inform the Contractor if the entire test or only the portion that failed shall be re-performed. Give the Government a written report of those items which failed, what the problem was, and what was done to correct it. Provide onsite technical support to perform the PVT. ATTACHMENT A presents the generic Test Procedures with the following information:

a. Test identification number.

b. Test title.

c. Objective.

d. Initial conditions (if applicable).

e. Test equipment (if required).

f. Sequence of events.

g. Expected results.

3.4.3 Test Report

Submit a factory final, complete test report after completing the test, consisting of the following, as a minimum:

a. Section one of the submittal shall be a short summary of the factory test.

b. Section two of the submittal shall be a copy of the test plans.

c. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

3.5 FIELD TEST REQUIREMENTS

The UMCS contractor shall perform and document contractor start-up and field tests as required by Sections 25 10 10 LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS) and 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS. The field test validates that the UMCS and building level DDC are in operation without any problems or system errors prior to starting a PVT. Validate that all software along with all hardware is installed to meet or exceed the contract document requirements. This includes all LONWORKS(r) networking and monitoring hardware and all peripherals associated with the network and hardware. Start-up and field testing shall include:

a. Start-up Testing: All testing listed in Sections 25 10 10 and 23 09 23 shall be completed.

b. Point-to-Point Testing: All point-to-point testing of end field devices through proper input/output to graphic and operator interface shall be completed and approved.

c. All field calibration shall be completed and approved.

d. Detailed functional tests, verified by the Government that the system operation adheres to the Sequences of Operation.

e. Alarms and Interlocks: All alarm limits and testing shall be completed.

f. System schedules and setpoints: All schedule start/stops and system setpoints shall be entered, operating, and approved.

3.6 PERFORMANCE VERIFICATION TEST

3.6.1 Test Plan

Prior to the scheduling of the performance verification tests, provide the Government with a Performance Verification and Endurance Test Plan and Procedures for approval, and receive notification of approval of the Test Plan and Procedures. The plan shall include the following, as a minimum:

a. Installed system one-line block diagram, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.

b. Installed system hardware description.

c. Installed system software description, including any software revisions made since the factory test.

d. Listing of control and status points installed in the system; plus a table with the following information:

1). Input and output variables.
2). SNVTs for each variable.
3). Expected engineering units for each variable.
4). Node ID.
5). Domain & subnet addressing.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.6.2 Test Procedures

Develop the performance verification test procedures from the generic test procedures in ATTACHMENT A. The test procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. Edit the generic test procedure for the provided UMCS and building level DDC. Perform a performance verification test (PVT) on the completed UMCS and building level DDC for the Government to verify the system is completely functional. If, during testing, the system fails a portion of a test, the Government will inform the Contractor if the entire test or only the portion that failed shall be re-performed. Give the Government a written report of those items which failed, what the problem was, and what was done to correct it. Provide on-site technical support to perform the PVT. ATTACHMENT A presents the generic UMCS Performance Verification Test Procedures with the following information:

a. Test identification number.

b. Test title.

c. Objective.

d. Initial conditions (if applicable).

e. Test equipment (if required).

f. Sequence of events.

g. Expected results.

3.6.3 Test Report

Submit a final, complete PVT test report, after completing the test, consisting of the following, as a minimum:

a. Section one of the submittal shall be a short summary of the performance verification test.

b. Section two of the submittal shall be a copy of the test plans.

c. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

3.7 ENDURANCE TESTING

3.7.1 General

Endurance Test shall be designed to demonstrate the specified overall system reliability requirement of the completed system. Conduct the Endurance Test in four phases as described below. The Endurance Test shall not be started until the Government notifies the Contractor, in writing, that the Performance Verification Tests have been satisfactorily completed, training as specified has been completed, correction of all outstanding deficiencies has been satisfactorily completed, and that the Contractor has permission to start the Endurance Test. Provide an operator to man the system eight hours per day during first shift operations, including weekends and holidays, during Phase I and Phase III Endurance testing, in addition to any Government personnel that may be made available. The Government may terminate testing at any time if the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, commence an assessment period as described for Phase II and Phase IV. Upon successful completion of the Endurance Test, submit test reports to the Government explaining in detail the nature of any failures, corrective action taken, and results of tests performed, prior to acceptance of the system. Keep a record of the time and cause of each outage that takes place during the test period.

3.7.2 Phase I

During the Phase I testing, operate the system as specified for 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays. Do not make repairs during this phase of testing unless authorized by the Government, in writing. If the system experiences no failures during the Phase I test, proceed directly to Phase III testing, after receiving written permission from the Government.

3.7.3 Phase II

In Phase II, which occurs after the conclusion of Phase I, identify all failures, determine the causes of all failures, repair all failures, and submit a test failure report to the Government. After submitting the written report, convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall be scheduled no earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that all failures have been corrected by performing appropriate Performance Verification Tests. Based on the Contractor's report, the test review meeting, and the Contractor's recommendation, the Government will independently determine the restart point and may require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Government.

3.7.4 Phase III

After the conclusion of any retesting which the Government may require, repeat the Phase II assessment as if Phase I had just been completed. If the retest is completed without any failures, proceed directly to Phase III testing, after receiving written permission from the Government. During Phase III testing, operate the system as specified for 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays. Do not make repairs during this phase of testing unless authorized by the Government, in writing.

3.7.5 Phase IV

In Phase IV, which occurs after the conclusion of Phase III, identify all failures, determine the causes of all failures, repair all failures, and submit a test failure report to the Government. After submitting the written report, convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall not be scheduled earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that all failures have been corrected by performing appropriate Performance Verification Tests. Based on the Contractor's report, the test review meeting, and the Contractor's recommendation, the Government will independently determine the restart point and may require that the Phase III test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Government. After the conclusion of any retesting which the Government may require, the Phase IV assessment shall be repeated as if Phase III had just been completed. The Contractor will not be held responsible for failures resulting from the following:

a. An outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the UMCS performed as specified.

b. Failure of a Government-furnished communications link, provided that the LON nodes and LON routers automatically and correctly operate in the stand-alone mode as specified, and that the failure was not due to contractor furnished equipment, installation, or software.

c. Failure of existing Government-owned equipment, provided that the failure was not due to contractor-furnished equipment, installation, or software.

3.7.6 Failure Reports

Provide UMCS Endurance Test Failure Reports. UMCS Test Failure Reports shall explain in detail the nature of each failure, corrective action taken, results of tests performed. If any failures occur during Phase I or Phase III testing, recommend the point at which the Phase I or Phase III testing, as applicable, should be resumed.

3.8 ATTACHMENT A

TEST PROCEDURES

TITLE: Test Index
OBJECTIVE: The following is an index of tests.

NOTES: Tests one through twenty contain specific "item(s)" that apply to Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS (UMCS) and 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING SYSTEMS. The following index of tests provides a summary of which "items numbers" apply to which specification.

Test No.	Test Title	Sect 25 10 10, UMCS	Sect 23 09 23, DDC for HVAC
One	Initial System Equipment Verification	Items 1 thru 15	Items 16 thru 32
Two	System Start-up	Items 1 thru 4	Items 5 and 6
Three	Monitor and Control Software	Items 1 thru 5	Not Applicable
Four	Graphic Display of Data	Items 1 thru 18	Not Applicable
Five	Graphic Navigation Scheme	Items 1 and 2	Not Applicable
Six	Command Functions	Items 1 thru 6	Not Applicable
Seven	Command Input Errors	Items 1 thru 6	Items 1 thru 6
Eight	Special Functions	Item 1	Not Applicable
Nine	Software Editing Tools	Items 1 thru 42	Items 1 thru 42
Ten	Scheduling	Items 1 thru 7	Items 8 thru 10
Eleven	Alarm function	Items 1 thru 15	Item 16
Twelve	Trending	Items 1 thru 8	Not Applicable
Thirteen	Demand Limiting	Items 1 thru 8	Not Applicable
Fourteen	Report Generation	Items 1 thru 6	Not Applicable
Fifteen	UPS Test	Items 1 thru 5	Not Applicable
Sixteen	CEA-709.1-D to IP Router Test	Items 1 thru 3	Not Applicable
Seventeen	CEA-709.1-D Router and Repeater	Not Applicable	Items 1 thru 4
Eighteen	CEA-709.1-D Gateway Test	Items 1 thru 5	Items 1 thru 5
Nineteen	Local Display Panel	Not Applicable	Items 1 thru 5
Twenty	Network Configuration Tool	Items 1 thru 8	Items 1 thru 8

Test No.	Test Title	Sect 25 10 10, UMCS	Sect 23 09 23, DDC for HVAC
Twenty-One	Custom Tests	Item 1 and 2	Item 1 and 2

PVT Checklist

OBJECTIVE:

1. Inspect/test/verify that building-level DDC system is compliant with Section 23 09 23 and capable of integration with UMCS

INITIAL REQUIREMENTS/CONDITIONS

1. The following tests shall be completed and documentation shall be submitted to the Government.

2. Date of Checklist: ___________
3. Time of Checklist: ___________
4. Contractor's Representative: ______________________
5. Government's Representative: ______________________

CHECKLIST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Draft or Final As-Built Drawings	Drawings submitted and approved	___________
		Point schedule(s) showing all required UMCS SNVTs submitted	___________
		Point schedules(s) showing device network addresses submitted	___________
		Local display panel (LDP) locations indicated on drawings submitted	___________
	Notes: ______________________________		
2	Network Bandwidth Test Report	Test completed, accepted, and a report documenting results submitted	___________
	Notes: ______________________________		
3	Programming software	Most recent version of the programming software for each type of GPPC has been submitted	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	XIF Files	External interface files (XIF) files for each model of LONWORKS®-based DDC hardware has been submitted	____
	Notes: ____		
5	LNS Database	Copies of the LNS database for the completed control network has been submitted	____
	Notes: ____		
6	LNS Plug-in	LNS Plug-ins for each application specific controller has been submitted	____
	Notes: ____		
7	Start-up testing report	Start-up has been successfully completed and testing report submitted	____
		Controller tuning has been completed and document on point schedule	____
		Calibration accuracy check completed and documented in test report	____
		Actuator range check completed and documented in test report	____
		Functional test to demonstrate control sequence completed and documented in test report	____
	Notes: ____		
8	Software License	Software licenses received for all software on the project	____
	Notes: ____		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: One
TITLE: Initial System Equipment Verification

OBJECTIVE:

1. To verify that the hardware and software components of the system provided by the Contractor are in accordance with the contract plans and specifications and all approved submittals.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submit a detailed list of all approved hardware with Manufacturer, model number and location. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which shall be available for reference purposes during the test.

b. Submit a detailed list of all approved software with revision number and purpose of software. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which shall be available for reference purposes during the test.

2. Equipment

a. Verify all equipment is functional.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	The workstation hardware is installed and complies with specification paragraph titled "Workstation Hardware".	__________________	___________
	Notes: ______________________________		
2	The Server hardware is installed and complies with specification paragraph titled "Server Hardware".	__________________	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
3	The fiber optic patch panel is installed and complies with specification paragraph titled "Fiber Optic Patch Panel".	____________	________
	Notes: ______________________________		
4	The fiber optic media converter is installed and complies with specification paragraph titled "Fiber Optic Media Converter".	____________	________
	Notes: ______________________________		
5	The Ethernet switch is installed and complies with specification paragraph titled "Ethernet Switch".	____________	________
	Notes: ______________________________		
6	The IP router is installed and complies with specification paragraph titled "IP Router".	____________	________
	Notes: ______________________________		
7	The CEA-709.1-D to IP router is installed and complies with specification paragraph titled "CEA-709.1-D to IP Router".	____________	________
	Notes: ______________________________		
8	The CEA-709.1-D gateway is installed and complies with specification paragraph titled "CEA-709.1-D Gateway".	____________	________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
9	The alarm printer is installed and complies with specification paragraphs titled "PRINTERS" and "Alarm Printer".	________	________
	Notes: ________		
10	The laser printer is installed and complies with specification paragraphs titled "PRINTERS" and "Laser Printer".	________	________
	Notes: ________		
11	The color printer is installed and complies with specification paragraphs titled "PRINTERS" and "Color Printer".	________	________
	Notes: ________		
12	The operating system is installed and complies with specification paragraph titled "Operating System (OS)".	________	________
	Notes: ________		
13	The office automation software is installed and complies with specification paragraph titled "Office Automation Software".	________	________
	Notes: ________		
14	The virus protection software is installed and complies with specification paragraph titled "Virus Protection Software".	________	________
	Notes: ________		
15	The configuration server is installed and complies with specification paragraph titled		

Item	Action Item	Expected Results	Approved
	"CEA-852-C Configuration Server".	____________	____________
	Notes: ______________________________		

DDC FOR HVAC

Item	Action Item	Expected Results	Approved
16	The CEA-709.1-D Router is installed and complies with specification paragraph titled "CEA-709.1-D Router".	____________	____________
	Notes: ______________________________		
17	The CEA-709.3 Repeater is installed and complies with specification paragraph titled "CEA-709.3 Repeater".	____________	____________
	Notes: ______________________________		
18	The TP/FT-10 network is installed in accordance with CEA-709.3, with double-terminated bus topology.	____________	____________
	Notes: ______________________________		
19	Network wiring extends to the location of UMCS BPOC.	____________	____________
	Notes: ______________________________		
20	The Gateway is installed and complies with specification paragraph titled "Gateway".	____________	____________
	Notes: ______________________________		
21	All control valves are installed and comply with their associated specification paragraph under the section titled "Control Valves".	____________	____________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
22	All dampers are installed and comply with their associated specification paragraph under the section titled "Dampers".	______	______
	Notes: ______		
23	All sensors are installed and comply with their associated specification paragraph under the section titled "Sensors".	______	______
	Notes: ______		
24	All indicating devices are installed and comply with their associated specification paragraph under the section titled "Indicating Devices".	______	______
	Notes: ______		
25	All user input devices are installed and comply with their associated specification paragraph under the section titled "User Input Devices".	______	______
	Notes: ______		
26	All output devices are installed and comply with their associated specification paragraph under the section titled "Output Devices".	______	______
	Notes: ______		
27	All multifunction devices are installed and comply with their associated specification paragraph under the section titled "Multifunction Devices".	______	______
	Notes: ______		

Item	Action Item	Expected Results	Approved
28	All compressed air equipment is installed and complies with their associated specification paragraph under the section titled "Compressed Air".	________	________
	Notes: ________		
29	All ASCs are installed and comply with the specification paragraph titled "Application Specific Controller".	________	________
	Notes: ________		
30	All LDPs and laptop computers are provided and comply with the specification paragraph titled "Local Display Panel".	________	________
	Notes: ________		
31	All GPPCs are installed and comply with the specification paragraph titled "General Purpose Programmable Controller".	________	________
	Notes: ________		
32	LNS-based system used to address nodes, bind variables, and LNS database of network exists on system.	________	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Two
TITLE: System Start-up

OBJECTIVE:

1. To validate that the system properly initializes and that the GUI properly reconnects to all communicating devices.
2. To validate that both application specific and programmable devices retain all vital information upon a power cycle.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide a list of all software that will be used to verify point connection at field level controllers and user interface.

   b. Provide a list of all software need to verify application specific and programmable controller start-up.

2. Equipment

   a. All peripherals and cables shall be connected in accordance with manufacturer's requirements.

   b. The workstation shall be in the off mode.

   c. All controls shall be fully functional and tested.

   d. A programmable and application specific controller shall be randomly selected for the test.

3. Date of Test: ___________
4. Time of Test: ___________
5. Contractor's Representative: ______________________
6. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Energize the workstation.	The workstation will power-up and perform its start-up procedure without generating any errors or problems.	___________
	a) Operating system	Operating system shall be latest version of windows.	___________
	b) Start Network Configuration Tool.	The Network Configuration Tool drawing will open.	___________
	c) Start the System Plug-in.	The System plug-in will open.	___________
	d) Start the Server.	The Server will start.	___________
	e) Start the Workstation.	The Workstation will start. The operator shall now have the ability to view data from any device on the	

Item	Action Item	Expected Results	Approved
		network.	___________
	Notes: ______________________________		
2	Check the communication from the server to the controllers.	Within the workstation software, when a device is selected, dynamic points lists become visible. Dynamic data represents success. A completion event failure message represents failure.	___________
	Notes: ______________________________		
3	Verify on-line status.	All devices shall have on-line status indicated by the workstation software (green indicator).	___________
	Notes: ______________________________		
4	View data from the graphical environment.	When a graphics page is opened, the points on the page should update. Question marks in lieu of data reflect failure.	___________
	Notes: ______________________________		
DDC FOR HVAC			
5	Verify that configuration data in application specific controllers is written to EEPROM.	All configuration parameters should be accessible.	___________
	a) Open the LONWORKS® plug-in.	Software should open without errors.	___________
	b) Note several parameters such as temperature setpoints and flow settings.	Operator is able to view a sample of parameters (data values and setpoints).	___________
	c) Remove power from the controller for a minimum of 3 minutes.	Device should go off-line in Network Configuration Tool and workstation/server.	___________
	d) Replace power to the controller.	Device should return to on-line status.	___________
	e) Using the plug-in, verify that the parameters have not	Parameters shall not have changed.	___________

Item	Action Item	Expected Results	Approved
	changes.		
	Notes: ______		
6	Verify that configuration data in programmable controllers is retained after a power cycle.	______	______
	a) From the Workstation view several configuration parameters and note the values.	Values of the parameters can be viewed from the tree structure.	______
	b) Remove power for a minimum of 3 minutes.	Controller will go offline in workstation software.	______
	c) Replace power to the controller.	Controller will return to online status.	______
	d) From the Workstation view the same configuration parameters and note the values.	Parameters values shall not have changed.	______
	Notes: ______		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Three
TITLE: Monitor and Control (M&C) Software Passwords

OBJECTIVE:

1. To validate that the system utilizes four basic password levels
2. To validate that each password level has the specified authority

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of M&C user password capacity in comparison with specification.

b. Provide a complete list of all users along with their passwords and user level prior to testing.

2. Equipment

a. Server and Workstation

3. Reference Documentation

a. Provide user manual documentation for setting up passwords

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Create password for new users.	New users shall exist in the server Database.	___________
	a) Set-up 4 users.	________________	___________
	b) Assign different levels to each.	________________	___________
	Notes: ______________________________		
2	Demonstrate level 1 authority.	________________	___________
	a) Sign in as the level 1 user.	Sign in shall be successful.	___________
	b) Attempt to view a system graphic.	Action shall be possible.	___________
	c) Attempt to acknowledge an alarm.	Action shall be denied.	___________
	d) Attempt to configure a trend.	Action shall be denied.	___________
	e) Attempt to configure a report.	Action shall be denied.	___________

Item	Action Item	Expected Results	Approved
	f) Attempt to override a point.	Action shall be denied.	___
	g) Attempt to configure an alarm.	Action shall be denied.	___
	h) Attempt to configure a schedule.	Action shall be denied.	___
	i) Attempt to configure a demand limiting parameter.	Action shall be denied.	___
	j) Attempt to modify a graphic page.	Action shall be denied.	___
	k) Attempt to create a custom program.	Action shall be denied.	___
	Notes: ___		
3	Demonstrate level 2 authority.	___	___
	a) Sign in as the level 2 user.	Sign in shall be successful.	___
	b) Attempt to view a system graphic.	Action shall be possible.	___
	c) Attempt to acknowledge an alarm.	Action shall be possible.	___
	d) Attempt to configure a trend.	Action shall be possible.	___
	e) Attempt to configure a report.	Action shall be possible.	___
	f) Attempt to override a point.	Action shall be denied.	___
	g) Attempt to configure an alarm.	Action shall be denied.	___
	h) Attempt to configure a schedule.	Action shall be denied.	___
	i) Attempt to configure a demand limiting parameter.	Action shall be denied.	___
	j) Attempt to modify a graphic page.	Action shall be denied.	___
	k) Attempt to create a custom program.	Action shall be denied.	___
	Notes: ___		
4	Demonstrate level 3 authority.	___	___
	a) Sign in as the level 3 user.	Sign in shall be successful.	___
	b) Attempt to view a system graphic.	Action shall be possible.	___
	c) Attempt to acknowledge an alarm.	Action shall be possible.	___
	d) Attempt to configure a	Action shall be possible.	

Item	Action Item		Expected Results	Approved
		trend.		____
	e)	Attempt to configure a report.	Action shall be possible.	____
	f)	Attempt to override a point.	Action shall be possible.	____
	g)	Attempt to configure an alarm.	Action shall be possible.	____
	h)	Attempt to configure a schedule.	Action shall be possible.	____
	i)	Attempt to configure a demand limiting parameter.	Action shall be possible.	____
	j)	Attempt to modify a graphic page.	Action shall be denied.	____
	k)	Attempt to create a custom program.	Action shall be denied.	____

Notes: ____

____

Item	Action Item		Expected Results	Approved
5	Demonstrate level 4 authority.		____	____
	a)	Sign in as the level 3 user.	Sign in shall be successful.	____
	b)	Attempt to view a system graphic.	Action shall be possible.	____
	c)	Attempt to acknowledge an alarm.	Action shall be possible.	____
	d)	Attempt to configure a trend.	Action shall be possible.	____
	e)	Attempt to configure a report.	Action shall be possible.	____
	f)	Attempt to override a point.	Action shall be possible.	____
	g)	Attempt to configure an alarm.	Action shall be possible.	____
	h)	Attempt to configure a schedule.	Action shall be possible.	____
	i)	Attempt to configure a demand limiting parameter.	Action shall be possible.	____
	j)	Attempt to modify a graphic page program.	Action shall be possible.	____
	k)	Attempt to create a custom program.	Action shall be possible.	____

Notes: ____

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Four
TITLE: Graphic Display of Data

OBJECTIVE:

1. To validate that floor plans and equipment can be graphically displayed through GUI.
2. To validate the proper display of alarms on GUI.
3. To validate the proper display of trend data on GUI.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

    a. Provide hard copies of "snap shots" of sample graphics pages prior to testing.

2. Equipment

    a. Complete all graphics.

3. Reference Documentation

    a. List user manual documentation and sections pertaining to the testing.

4. Notes

    a. Different types of data and states should be clearly distinguishable from each other.

5. Date of Test: ___________
6. Time of Test: ___________
7. Contractor's Representative: ______________________
8. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
1	Demonstrate the use of a three dimensional representation of a mechanical system.	Equipment shall be represented in a three dimensional manner.	___________
	Notes: ______________________________		
2	Demonstrate the presentation of real time data.	Dynamic real time data shall be presented on a graphics page.	___________
	Notes: ______________________________		
3	Demonstrate the presentation of user	A user defined parameter such as a setpoint shall be	

Item	Action Item	Expected Results	Approved
	entered data.	presented on a graphics page. Different types of data and states should be clearly distinguishable from each other.	________

Notes: ____________________

Item	Action Item	Expected Results	Approved
4	Demonstrate the presentation of a point in override.	An indication of override condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	________

Notes: ____________________

Item	Action Item	Expected Results	Approved
5	Demonstrate the presentation of a device in the alarm state.	An indication of the alarm state shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	________

Notes: ____________________

Item	Action Item	Expected Results	Approved
6	Demonstrate the presentation of data that is out of range.	An indication of out of range condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	________

Notes: ____________________

Item	Action Item	Expected Results	Approved
7	Demonstrate the presentation of missing data (controller is offline).	An indication of missing data shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	________

Notes: ____________________

Item	Action Item	Expected Results	Approved
8	Demonstrate an error message when the operator attempts to execute in improper command.	An error message shall be displayed.	________
	Notes: ________		
9	Demonstrate point and click access to context sensitive help.	Operator shall be able to easily access context sensitive help using the mouse.	________
	Notes: ________		
10	Demonstrate point and click access to an engineering diagram.	Operator shall be able to access an engineering diagram using the mouse.	________
	Notes: ________		
11	Demonstrate the creation of an engineering diagram.	Operator shall be able to create an engineering diagram.	________
	Notes: ________		
12	Demonstrate the printing of a prepared report.	Operator shall be able to print a report using the mouse.	________
	Notes: ________		
13	Demonstrate the display of one or more points.	Operator shall be able to request the display of one or more points.	________
	Notes: ________		
14	Demonstrate the operator override of a point.	Operator shall be able to override a point.	________
	Notes: ________		

Item	Action Item	Expected Results	Approved
15	Demonstrate the modification of a time schedule.	Operator shall be able to modify a time schedule.	___________
	Notes: ____________		
16	Demonstrate the execution of a report.	Operator shall be able to initiate a report.	___________
	Notes: ____________		
17	Demonstrate the presentation of an alarm to include:	Operator shall be able to view an alarm with all of the required data.	___________
	a) Identification	________________	___________
	b) Date and time	________________	___________
	c) Alarm Type	________________	___________
	d) Set Points	________________	___________
	e) Units	________________	___________
	f) Current Value	________________	___________
	g) Priority	________________	___________
	h) Associated message & Secondary message	________________	___________
	Notes: ____________		
18	Demonstrate the presentation of real time trend data.	Operator shall be able to view real time trend data as a function of time.	___________
	Notes: ____________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Five
TITLE: Graphic Navigation Scheme

OBJECTIVE:

1. To validate hierarchical graphic displays from main screen to end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide a hierarchical block diagram of the system network prior to testing.

2. Equipment

a. Have all programming completed to demonstrate graphic display.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the creation of a hierarchical tree structure for the presentation of point data with at least five levels.	Operator shall be able to organize point data graphic display in a hierarchical tree structure based on any organization desired. A typical organization could be: - Installation - Building - Building sub area - Main System-Unit - Terminal Unit	___________

Notes: ____

____

Item	Action Item	Expected Results	Approved
2	Demonstrate the creation of a hierarchical navigation structure for the graphic pages.	Operator shall be able or organize the graphical navigation from page to page using any hierarchical structure desired.	

Item	Action Item	Expected Results	Approved
		Examples: Home page to building 1 Building 1 to AHU 1 Building 1 back to Home Page Building 1 to 1st Floor Plan AHU 1 back to Building 1 AHU 1 back to Home Page AHU 1 to Terminal Unit Summary 1st Floor Plan back to Building 1 1st Floor Plan back to Home Page 1st Floor Plan to Any Terminal Device Terminal Unit Summary back to AHU 1 Terminal Unit Summary back to Building 1 Terminal Unit Summary back to Home Page Terminal Unit Summary to Individual Device	___________

Notes: ____

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Six
TITLE: Command Functions

OBJECTIVE:

1. To demonstrate the functionality and ability to execute command to the end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide documentation of all command functions prior to testing.

2. Equipment

   a. Have all command functions programmed and functional.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	From the tree structure, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of other dynamic points.	___________
	Notes: ____________________		
2	From a graphic page, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of dynamic points.	___________
	Notes: ____________________		
3	From the tree structure, place an analog output point under operator	The analog output point shall accept the assigned value and ignore changes	

Item	Action Item	Expected Results	Approved
	override and assign a fixed value.	from application logic until the point is taken out of override.	___________
	Notes: ___________		
4	From a graphic page, place an analog output point under operator override and assign a fixed value.	The analog output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	___________
	Notes: ___________		
5	From the tree structure, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	___________
	Notes: ___________		
6	From a graphic page, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	___________
	Notes: ___________		

End of Test

Specific Abbreviations:
- Y = Yes
- N = No
- NA = Not Applicable

TEST NUMBER: Seven
TITLE: Command Input Errors

OBJECTIVE:

1. To validate that the system ensures the necessary authority for command inputs
2. To validate that the system can control the range of command input values

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide all command input error messages prior to testing.

2. Equipment

   a. UMCS and DDC hardware and software

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Login using a password with point command.	Login occurs.	___________
	Notes: ______________________________		
2	Request a display of a SNVT.	The system displays the controllers SNVT value.	___________
	Notes: ______________________________		
3	Override the SNVT point to a selected value.	The SNVT value override changes the value in the controller.	___________
	Notes: ______________________________		
4	Release the override of	The SNVT value returns to	

Item	Action Item	Expected Results	Approved
	a SNVT.	normal.	________
	Notes: ________		
5	For an nvi to a controller with a limit of 50 to 80, command the nvi to a value of 90.	The value will go the maximum of 80.	________
	Notes: ________		
6	For an nvi to a controller for which the operator only has read privileges, command the nvi to a value of 90.	The operator will be denied the ability to command the nvi to any value.	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eight
TITLE: Special Functions

OBJECTIVE:

1. Verify system has special integration as defined.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide documentation of all integrations prior to testing.

2. Equipment

   a. Have all UMCS and DDC hardware and software programmed, integrated, and completed.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Verify that a building that uses controls from a vendor other than the one being installed can be integrated into the GUI without any loss of functionality. (A simulated building will be set up using an IP-L router and controllers from Honeywell, TAC, Trane, etc.)	Data from the other vendors controllers shall be integrated into the GUI and the same functionality that would exist if the controllers were from the same manufacture shall exist.	___________

Notes: ____

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nine
TITLE: Software editing tools

OBJECTIVE:

1. To validate the performance of the M & C application programming tool for the GPPC.
2. To validate the performance of the display editing tool.
3. To validate the performance of the report generation display tool.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation and a backup softcopy of the editing tool prior to testing.

b. Provide documentation of any future software upgrade versions that pertain to the software-editing tool.

2. Equipment

a. Have working knowledge of the full capability of the software-editing tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS and DDC for HVAC			
1	Demonstrate the programming of an override function in a GPPC.	Operator shall be able to use the programmed function to override an output point in a GPPC.	___________
	Notes: ______________________		
2	Demonstrate software that enables the monitoring of data from a GPPC.	Operator shall be able to monitor points from a GPPC.	___________
	Notes: ______________________		
3	Demonstrate timer	Control logic shall honor	

Item	Action Item	Expected Results	Approved
	functions within applications of GPPC.	the built in timers.	___________
	a) delay on	_______________	___________
	b) delay off	_______________	___________
	c) one second delays	_______________	___________
	d) interval timers	_______________	___________
	Notes: ______________________________		
4	Demonstrate logic loops ("for" and "while") in GPPC.	Control logic shall honor the criteria.	___________
	Notes: ______________________________		
5	Demonstrate if-then-else logic in GPPC.	Control logic shall properly follow the if, then, else requirements.	___________
	Notes: ______________________________		
6	Demonstrate basic math functions in GPPC.	Control logic shall properly execute math functions.	___________
	Notes: ______________________________		
7	Demonstrate Boolean math functions in GPPC.	Control logic shall properly execute the functions.	___________
	Notes: ______________________________		
8	Demonstrate exponential math functions in GPPC.	Control logic shall properly execute the functions.	___________
	Notes: ______________________________		
9	Demonstrate trigonometric math functions in GPPC.	Control logic shall properly execute the functions.	___________
	Notes: ______________________________		
10	Demonstrate bitwise math functions in GPPC.	Control logic shall properly execute the functions.	___________

Item	Action Item	Expected Results	Approved
	Notes:		
11	Create a user defined subroutine/function in GPPC.	Subroutine/function shall work correctly and be easily reused.	___
	Notes:		
12	Create alarm conditions in GPPC.	Alarm variables shall be created according to the criteria.	___
	Notes:		
13	Create and save a graphic symbol at the server.	Symbol shall be reusable on a new graphic.	___
	Notes:		
14	Modify a graphic symbol at the server.	Operator shall be able to open an existing symbol and make changes.	___
	Notes:		
15	Save a graphic symbol to a library at the server.	Symbol shall be available from the library for reuse.	___
	Notes:		
16	Delete a graphic symbol at the server.	Symbol shall no longer exist for use.	___
	Notes:		
17	Place a graphic symbol on a new graphic page at server.	When the new page is opened, the symbol shall be there.	___
	Notes:		

Item	Action Item	Expected Results	Approved
18	Associate particular conditions with particular displays at the server.	When the conditional variable changes, the display should change.	____________
	Notes: ______________________________		
19	Overlay alphanumeric text on a graphic at the server.	Text shall properly display.	____________
	Notes: ______________________________		
20	Create a new graphic from an old one at the server.	New graphic shall properly display.	____________
	Notes: ______________________________		
21	Place dynamic data on a graphic at the server.	The dynamic data shall be viewable on the graphic.	____________
	Notes: ______________________________		
22	Define the background color of a new graphic at the server.	The new graphic shall show the selected background color.	____________
	Notes: ______________________________		
23	Define a foreground color for an element on a graphic to distinguish it from the background color at the server.	The color of the dynamic data that uses the foreground color shall display in the foreground color.	____________
	Notes: ______________________________		
24	Position a symbol on a graphic at the server.	The operator shall be able to place a symbol at any location on a graphic.	____________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
25	Position and edit alphanumeric descriptors at the server.	The alphanumeric display shall be as designed.	________
	Notes: ________		
26	Draw lines on a graphic at the server.	Lines shall display as drawn.	________
	Notes: ________		
27	Associate source of dynamic data for presentation on a graphic at the server.	Correct data shall be displayed.	________
	Notes: ________		
28	Display analog data on a graphic page at the server.	Correct data shall be displayed.	________
	Notes: ________		
29	Demonstrate the movement of the curser (crosshairs) by the use of the mouse at the server.	Crosshairs shall follow the commands from the mouse.	________
	Notes: ________		
30	Demonstrate the simultaneous use of multiple graphics (coincident graphics)at the server.	Operator shall see the use of the tile function and the use of the tab function to manage multiple graphics.	________
	Notes: ________		
31	Associate graphic properties such as color with the values from dynamic variables at	Graphic properties shall change as the value of the dynamic variable changes.	

Item	Action Item	Expected Results	Approved
	the server.		___________
	Notes: ___________		
32	Create conditional displays based on the value of a dynamic variable at the server.	The graphic display shall change as the dynamic variable changes.	___________
	Notes: ___________		
33	Review the standard symbol library at the	Operator shall see how to access symbols from the standard symbol library.	___________
	Notes: ___________		
34	Demonstrate how to move data from the database to a report at the server.	The executed report shall contain data from the database.	___________
	Notes: ___________		
35	Add comments and headers to a report at the server.	The executed report shall contain the comments and headers.	___________
	Notes: ___________		
36	Demonstrate the time stamping of data in a report at the server.	Data presented in a report shall include the date and time the data was sampled.	___________
	Notes: ___________		
37	Demonstrate the time stamping of the report generation at the server.	A report shall include the date and time it executed.	___________
	Notes: ___________		
38	Demonstrate basic mathematical manipulation	Report shall display the results of the mathematical	

Item	Action Item	Expected Results	Approved
	of data within a report (daily averages, highs, lows, etc.) at the server.	manipulations.	___________
	Notes:		
39	Demonstrate the operator's ability to select either automatic or manual generation of a report.	Reports shall execute per the operator's instructions. Report one shall execute per the operator's instructions. Report two shall execute automatically on a time basis per operator's instructions.	___________
	Notes:		
40	Demonstrate the selection of either display, print to printer or print to file.	Reports shall execute per the operator's instructions. Report one is printed to printer. Report two is printed to file.	___________
	Notes:		
41	Demonstrate how a modified application program is imported into the server database for presentation to the workstations.	Modified list of variables shall be available from a workstation.	___________
	Notes:		
42	Demonstrate how a new device is added to the server database for presentation to the workstations.	New list of variables from the new device shall be available from a workstation.	___________
	Notes:		

End of Test

Item	Action Item	Expected Results	Approved

Specific Abbreviations:
- Y = Yes
- N = No
- NA = Not Applicable

TEST NUMBER: Ten
TITLE: Scheduling

OBJECTIVE:

1. Verify that M&C software has ability to operate end devices off a time of day schedule utilizing defined parameters.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of the minimum programmable schedules in comparison to the specification requirement prior to testing.

b. Provide documentation of all schedules programmed in the UMCS prior to testing.

c. Provide a trend or report log of all equipment on a schedule prior to testing.

2. Equipment

a. Have GPPC and ASC with all scheduling completed for testing.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the basic functionality of a time schedule by monitoring the value of SNVT_occupancy as the time changes through a start time or a stop time.	The value of SNVT_occupancy shall properly track the time schedule.	___________
	Notes: ______________________________		
2	Setup a weekly time schedule for a demo system with independent times for each day of the week and with up to 6 events per day.	Scheduling software shall accommodate the described requirements.	___________

Item	Action Item	Expected Results	Approved
	Notes: ______		
3	Setup a special event or date specific time schedule and verify that this schedule takes precedence over the weekly schedule.	The special event schedule shall take precedence.	______
	Notes: ______		
4	Setup a group time schedule for a collection of systems. This group schedule shall take precedence over the individual time schedules.	The group schedule shall take precedence.	______
	Notes: ______		
5	Demonstrate operator access to a time schedule from a graphic page.	Operator shall be able to access the time scheduling editor from a graphic page.	______
	Notes: ______		
6	Display the current date and time on a graphic page.	Operator shall be able to view the current date and time from a graphic page.	______
	Notes: ______		
7	Demonstrate automatic daylight savings time adjustment.	Time of day shifts automatically.	______
	Notes: ______		
HVAC			
8	Demonstrate the ability of GPPC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS or from "system scheduler" SNVT schedule data.	______

Item	Action Item	Expected Results	Approved
	Notes:		
9	Demonstrate the ability of ASC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS SVNT schedule data.	
	Notes:		
10	Demonstrate use of the default schedule when communication is lost to the UMCS.	Equipment should use the default schedule until communication is reestablished.	
	Notes:		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eleven
TITLE: Alarm Function

OBJECTIVE:

1. Verify M&C software is capable of alarm notification and routing.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of alarm managing capacity in caparison with specification.

b. Provide documentation of all alarm types and priorities utilized in the M&C prior to testing.

c. Provide documentation of the alarm routing in this particular M&C.

2. Equipment

a. Provide GPPC and ASC will alarms programmed.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Initiate a basic binary alarm condition such as a fan fail to start.	The nvo (SNVT) displayed on designated server/workstation shall change from a value of 0 to a value of 1. The alarm shall be presented in the alarm window. The alarm shall define the source of the alarm. The alarm shall define the time of the alarm. The alarm shall present its assigned priority. The alarm shall display a text message.	___________

Item	Action Item	Expected Results	Approved
	Notes: ________________		
2	Demonstrate the capability of associating a secondary text message with the alarm.	With a simple point and click, the operator shall have access to the secondary text message.	________
	Notes: ________________		
3	Acknowledge the alarm.	The status of the alarm shall changed to acknowledged. The user that acknowledged the alarm shall be recorded along with the date and time of the action.	________
	Notes: ________________		
4	Demonstrate the "pop up" of the alarm window when an alarm occurs.	When the alarm occurs, the alarm window shall automatically open.	________
	Notes: ________________		
5	Demonstrate the capability to send a numeric page when an alarm occurs.	The numeric page is received.	________
	Notes: ________________		
6	Demonstrate the capability to send an e-mail when an alarm occurs.	The e-mail shall be received.	________
	Notes: ________________		
7	Demonstrate the printing of an alarm on the alarm printer.	The printer shall print the alarm.	________
	Notes: ________________		

Item	Action Item	Expected Results	Approved
8	Identify the file on the hard disk that contains all of the alarms.	Opening the file shall display a list of all of the alarms.	___________
	Notes: ______________________________		
9	Execute a user sort on the alarm file.	The presentation shall follow the defined sort.	___________
	Notes: ______________________________		
10	Print the alarm file.	Paper copy shall be printed.	___________
	Notes: ______________________________		
11	Take an application specific controller off-line.	An alarm should be generated.	___________
	Notes: ______________________________		
12	Take a programmable controller off line.	An alarm should be generated.	___________
	Notes: ______________________________		
13	Simulate a data circuit going off line.	An alarm should be generated.	___________
	Notes: ______________________________		
14	Simulate a point not responding to a command.	An alarm should be generated.	___________
	Notes: ______________________________		
15	Simulate a change of state without command.	An alarm should be generated.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
16	Initiate an alarm condition such as a fan fail to start.	DDC system shall dial a pager and send a numerical alarm. DDC system shall dial an e-mail server. The node shall be able to dial and connect to a remote server and send an e-mail via Simple Mail Transfer Protocol (SMTP). DDC system shall send an e-mail over IP Network. The alarm handling node shall be capable of connecting to an IP network and sending e-mail via Simple Mail Transfer Protocol (SMTP).	___________

Notes: ____

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twelve
TITLE: Trending

OBJECTIVE:

1. To validate the capability for historical trend data collection and presentation

2. To validate the capability for real time trend data collection and presentation

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide documentation of trending capability in comparison with specification.

2. Equipment

   a. Provide GPPC or ASC and workstation/server programmed with trend data.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Set up a trend with a 1 second sample rate.	It shall be possible to collect data on a 1 second sample rate.	__________
	Notes: ____________________		
2	Set up a trend to start and stop at specific times.	It shall be possible to start and stop a trend based on time.	__________
	Notes: ____________________		
3	Open a trend data display that has 8 values trended versus time.	Trend plots shall show all 8 variables as a function of time.	__________
	a) historical data	________________	__________

Item	Action Item	Expected Results	Approved
	b) instantaneous data	________________	__________
	Notes:		
4	Open a pre-programmed trend data presentation.	Trend plot shall open without operator programming.	__________
	Notes:		
5	Open the trend configuration dialog box and set up a trend.	Operator shall be able to configure a trend plot.	__________
	Notes:		
6	Set up a trend for a randomly selected binary value and a randomly selected analog value.	Any binary or analog variable shall be trendable.	__________
	Notes:		
7	Verify that historical trend data is stored on the hard drive.	With the controller offline, historical trend data from that controller shall be presented in a graphical form.	__________
	Notes:		
8	Export trend log data to Microsoft Excel for manipulation and printing by the operator.	Data shall be presented in a ****.xls form.	__________
	Notes:		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Thirteen
TITLE: Demand Limiting

OBJECTIVE:

1. Verify M&C software has the capability of performing demand-limiting strategies

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of the specific equipment being monitored.

b. Provide documentation of the load shed priority and the equipment associated with the priorities.

2. Equipment

a. Provide GPPC and ASC programmed for demand-limit strategies.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	From the home page of the M&C go to or click on the graphical demand-limiting page.	The demand-limiting page will open without any errors.	___________
	Notes: ______________________________		
2	Document the present kW load__________.	The M&C will display the actual kW.	___________
	Notes: ______________________________		
3	Set kW limit setpoint to cause program to shed load.	_________________	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	Turn off 25% of the mechanical equipment being monitored.	The kW usage will decrease.	________
	Notes: ________		
5	Allow the building(s) to remain at 75% for a given time as to generate a temperature load.	The building(s) will warm-up/cool down.	________
	Notes: ________		
6	After time period has expired, turn all equipment on at the same time.	The kW usage will greatly increase. The M&C will stop other pieces of equipment as to shed the load. The equipment shut down will be priority based. After the building(s) come under temperature control the M&C will start all of the equipment. The equipment start up will be priority based.	________
	Notes: ________		
7	Verify the building(s) remain under temperature control and go back to the home page.	The building(s) will come under control. The home page will be displayed.	________
	Notes: ________		
8	Reset kW setpoint to normal limits.	The UMCS goes back to normal control.	________
	Notes: ________		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fourteen
TITLE: Report Generation

OBJECTIVE:

1. To demonstrate that M&C software has ability to generate reports in a fixed format initialized by operator request

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of all report logs set-up and the equipment associated with the report logs.

2. Equipment

a. Provide server/workstation, GPPC, ASC and I/O to create reports.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Manually generate a report for viewing on the workstation.	Report shall present itself for viewing without disrupting the operation of the control system.	___________
	Notes: ______________________________		
2	Manually generate a report and direct it to a specific printer.	Report shall print on the specified printer.	___________
	Notes: ______________________________		
3	Verify that the report contains the date and time associated with the raw data.	Data samples listed in the report shall have the associated date and time the samples were collected.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	Verify that the report has the date and time the report was generated.	The report shall include the date and time of the report generation.	____________
	Notes: ____________		
5	Save a report to a file that is compatible with Microsoft Office products.	The report shall be saved in a ***.xls format.	____________
	Notes: ____________		
6	Generate a comma delimited file with trend log data.	The comma delimited data shall be produced.	____________
	Notes: ____________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fifteen
TITLE: UPS Test

OBJECTIVE:

1. Validate UPS requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. The Contractor provides documentation on UPS.

2. Equipment

   a. The server/workstation and the UPS needs to be on and operating for a minimum of one week.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	The UMCS home graphic page is called up.	The home page is displayed.	___________
	Notes: ______________________________		
2	Unplug the UPS from the wall outlet.	The UMCS home page remains displayed. UPS LED-warning lights if applicable. UPS sound audible warning alarm if applicable.	___________
	Notes: ______________________________		
3	Log out of the home page of the M&C and then log back into it.	The UPS will not affect the UMCS hardware and all associated software.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	Allow the UPS to be unplugged for 20 minutes.	The UPS will not affect the UMCS hardware and all associated software.	________
	Notes: ________________________________		
5	Return the UPS plug to the wall outlet.	The UPS will not affect the UMCS hardware and all associated software.	________
	Notes: ________________________________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Sixteen
TITLE: CEA-709.1-D to IP Router Test

OBJECTIVE:

1. Validate CEA-709.1-D to IP Router requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submittal information on router and O&M manual on network analysis tool.

2. Equipment

a. The router needs to be on and operating.

b. Provide a LONWORKS® network analysis tool and router configuration tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Connect and open network analysis tool and verify router.	Tool shall identify function, network address, and identifier of the device.	___________
	Notes: ______________________________		
2	Using router configuration tool, open network properties dialog box.	Router shall be utilizing a static IP address and shall not be configured for DHCP.	___________
	Notes: ______________________________		
3	Confirm LON data is transmitted to/from LON bus to IP network.	All LONWORKS® network data is being transmitted to/from the IP network.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Seventeen
TITLE: CEA-709.1-D Router and Repeater

OBJECTIVE:

1. Validate EIA-709.1B Router and Repeater requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

    a. Submittal information on router/repeater and O&M Manual on network analysis tool.

2. Equipment

    a. The router needs to be on and operating for a minimum of one week.

    b. The repeater needs to be on and operating for a minimum of one week.

    c. Provide a LONWORKS® network analysis tool and router/repeater configuration tool.

3. Reference Documentation

    a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect and open network analysis tool and verify router and repeater.	Tool shall identify function, network address, and identifier of the devices.	___________
	Notes: ______________________________		
2	Using router configuration tool, open the properties dialog box. Verify what data is configured to pass through router.	Only the data that is configured to pass through the router is being sent.	___________
	Notes: ______________________________		
3	Using repeater	Dialog box opens.	

Item	Action Item	Expected Results	Approved
	configuration tool, open the properties dialog box.		____________
	Notes: ____________		
4	Verify that repeater is configured as a repeater and that all data is being sent.	Verify that all data is being sent through the repeater.	____________
	Notes: ____________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eighteen
TITLE: CEA-709.1-D Gateway Test

OBJECTIVE:

1. Validate CEA-709.1-D Gateway requirements.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide a list of all software that will be used to verify CEA-709.1-D Gateway configuration.

   b. Provide a LonMark external interface file (XIF) for the gateway.

2. Equipment

   a. The gateway needs to be on and operating.

   b. Provide a LonWorks® network analysis tool and gateway configuration tool.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS and DDC FOR HVAC			
1	Connect a LONWORKS® Network Analysis Tool to the network.	a. Tool shall identify function, network address, and identifier of the device. b. All network traffic from gateway shall be utilizing the CEA-709.1-D protocol.	___________

Notes: ____

____

Item	Action Item	Expected Results	Approved
2	Use gateway configuration tool to verify or create a binding from gateway to a LONWORKS® controller on the network.	a. Gateway allows binding of the Standard Network Variable Types from the gateway to a LONWORKS® controller. b. Information from gateway should be bounded and	

Item	Action Item	Expected Results	Approved
		LONWORKS® controller should be receiving data.	________
	Notes: ________		
3	Using gateway or network configuration tool verify the following:		
	Open the properties dialog box for one of the configured SNVTs.	Gateway should allow the SNVT to be transmitted on "min", "max" and "delta".	________
	Rename one of the SNVTs from the gateway.	Gateway should allow all variable names to be customized.	________
	Check total capacity of Gateway.	Gateway shall have 50% extra capacity to map over additional points.	________
	Notes: ________		
4	Press service pin on gateway.	Gateway should broadcast the neuron ID and Program ID over the network.	________
	Notes: ________		
5	Remove power source from gateway for two hours. Then return power to gateway.	Gateway should retain all configuration data.	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nineteen
TITLE: Local Display Panel (LDP)

OBJECTIVE:

1. To demonstrate capability of the Local display panel to view and override control points

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. O & M Manual for LDP

2. Equipment

   a. Hardware and software to connect and demo LDP configuration tool

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect LDP to LON bus. Push service pin button on LDP.	LDP Controller should broadcast its neuron ID.	___________
	Notes: ______________________________		
2	Use navigation buttons on LDP to display a status point such as a temperature or fan status.	LCP should allow user to read all status points.	___________
	Notes: ______________________________		
3	Use navigation buttons to display a control point such as a discharge air temperature setpoint.	LCP should allow user to read all control points.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	Use LDP to override setpoint.	System accepts new setpoint. Verify system reacts to new setpoint.	________
	Notes: ________		
5	Use LDP to release local control override.	Verify system returns to normal control.	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twenty
TITLE: Network Configuration Tool

OBJECTIVE:

1. To validate the performance of the network configuration tool

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. Network configuration tool manuals

2. Equipment

   a. Hardware, network connection, LNS database, and network configuration tool

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Open network configuration tool and verify LNS data for project opens is being used.	The Network Configuration Tool is being used and entire LNS database for project is exposed.	___________
	Notes: ______________________		
2	Open a typical LNS plug-in.	Plug-in shall open and enable configuration of the device.	___________
	Notes: ______________________		
3	Reconstruct a database by connecting to an existing network and uploading the data.	The database and drawing shall be created.	___________
	Notes: ______________________		

Item	Action Item	Expected Results	Approved
4	Verify that a graphical interface is use.	Note that Network Configuration Tool uses Visio (type) as a graphical interface.	____
	Notes: ____		
5	Print the graphical representation.	Printing shall be successful.	____
	Notes: ____		
6	Merge two LNS databases into a single database.	The merge shall be successful.	____
	Notes: ____		
7	Print reports from network configuration tool.	Address table, SNVT I/O table, and SCPT/UCPT table reports shall be successfully printed.	____
	Notes: ____		
8	Randomly select a sample of network variable and confirm they are using correct SNVT types.	Correct SNVT types were used.	____
	Notes: ____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twenty one
TITLE: Custom Tests

OBJECTIVE:

1. To test custom applications for UMCS and/or DDC for HVAC, that are specific to a project

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. Documents related to custom application - to be identified

2. Equipment

   a. Equipment to be provided related to custom application - to be identified

3. Date of Test: ___________
4. Time of Test: ___________
5. Contractor's Representative: ______________________
6. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Identify special tests for the UMCS that relate to a custom application for a specific project - to be completed by designer.	To be completed by designer.	___________
	Notes: ______________________		
2	Identify special tests for the DDC for HVAC systems that relate to a custom application for a specific project - to be completed by designer.	To be completed by designer.	___________
	Notes: ______________________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

-- End of Section --

SECTION 25 10 10

LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI INCITS 154	(1988; R 2004) Office Machines and Supplies - Alphanumeric Machines - Keyboard Arrangement

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE FUN IP	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, SI Edition

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2004) Free-Topology Twisted-Pair Channel Specification
CEA-852-C	(2014) Tunneling Component Network Protocols Over Internet Protocol Channels

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNET ENGINEERING TASK FORCE (IETF)

RFC 821	(2001) Simple Mail Transfer Protocol (SMTP)

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4

LonMark SNVT List	(2003) LonMark SNVT Master List; Version 113
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.402

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 262	(2015) Standard method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-606	(2012b) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC EMC	(2002) FCC Electromagnetic Compliance Requirements
FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1778	(2014) Uninterruptible Power Systems
UL 60950	(2000; Reprint Oct 2007) Safety of Information Technology Equipment
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment

1.2 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in this Section but are included here for completeness.

a. Application Generic Controller (AGC): A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the Program ID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

b. Application Specific Controller (ASC): A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e., Program ID) with configurable settings.

c. Binary: A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

d. Binding: The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent.

e. Building Control Network (BCN): The CEA-709.1-D control network consisting of one or more TP/FT-10 channels, and possibly a single TP/XF-1250 channel, in doubly terminated bus topology.

f. Building Point of Connection (BPOC): The BPOC is the point of connection between the UMCS network backbone (an IP network) and the building control network backbone. The hardware at this location, which provides the connection, is referred to as the BPOC Hardware. In general, the term "BPOC Location" means the place where this connection occurs, and "BPOC Hardware" means the device that provides the connection. Sometimes the term "BPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

g. Channel: A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

h. Commandable: See Overridable.

i. Configuration Property: Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see 'Standard Configuration Property Type (SCPT)'.

j. Control Logic Diagram: A graphical representation of control logic for multiple processes that make up a system.

k. Domain: A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) See also Node Address.

l. Explicit Messaging: A non-standard and often vendor (application) specific method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received.

m. External Interface File (XIF): A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

n. Functional Profile: A standard description, defined by LonMark, of one or more LonMark Objects used to classify and certify devices.

o. Gateway: A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

p. General Purpose Programmable Controller (GPPC): Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed Program ID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the Program ID will change.

q. LonMark Object: A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

r. LNS Plug-in: Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a 'user friendly' method to edit a device's configuration properties.

s. LonMark: See LonMark International. Also, a certification issued by LonMark International to CEA-709.1-D devices.

t. LonMark International: Standards committee consisting of numerous independent product developers, system integrators and end users dedicated to determining and maintaining the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

u. LonMark Interoperability Association: See 'LonMark International'.

v. LonWorks: The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), including the protocol itself, network management, interoperability guidelines and products.

w. LonWorks Network Services (LNS): A network management and database standard for CEA-709.1-D devices.

x. Monitoring and Control (M&C) Software: The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

y. Network Variable: See 'Standard Network Variable Type (SNVT)'.

z. Network Configuration Tool: The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

aa. Node: A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

bb. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

cc. Node ID: A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

dd. Overridable: A point is overridable if its value can be changed using network variables outside of the normal sequence of operations where this change has priority over the sequence. Typically this override is from the Utility Monitoring and Control System (UMCS) Monitoring and Control (M&C) Software. Note that that this definition is not standard throughout industry; some refer to this capability as "commandable" and some use this term to refer to changing a value from a configuration tool.

ee. Polling: A device requesting data from another device.

ff. Program ID: An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

gg. Repeater: A device that connects two control network segments and retransmits all information received on one side onto the other.

hh. Router: A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

ii. Segment: A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

jj. Service Pin: A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID. This broadcast can also be initiated via software.

kk. Standard Configuration Property Type (SCPT): Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Properties.

ll. Standard Network Variable Type (SNVT): Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

mm. Subnet: Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also Node Address.

nn. TP/FT-10: A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

oo. TP/XF-1250: A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

pp. UMCS Network: An IP network connecting multiple building control networks (BCNs) to the Monitoring and Control Software using the CEA-852-C standard.

qq. User-defined Configuration Property Type (UCPT): Pronounced 'u-keep-it'. A Configuration Property format type that is defined by the device manufacturer.

rr. User-defined Network Variable Type (UNVT): A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.3 SYSTEM DESCRIPTION

The Utility Monitoring and Control System (UMCS) shall perform supervisory control and monitoring of a base-wide CEA-709.1-D (LonWorks) network using LonWorks Network Services (LNS) as specified and shown. The UMCS shall interface to local CEA-709.1-D building controls installed per Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC BUILDING CONTROL SYSTEMS, as well as existing legacy systems. The UMCS shall maintain the LNS database(s) for the entire network.

1.3.1 System Requirements

Provide a UMCS in accordance with UL 916 and with the following characteristics:

a. The UMCS shall communicate CEA-709.1-D over the Government furnished IP network or an IP network as shown and specified and shall interface to building level control networks using CEA-852-C and CEA-709.1-D to IP Routers as specified.

b. The system shall perform supervisory monitoring and control functions including but not limited to Scheduling, Alarm Handling, Trending, Report Generation and Electrical Demand Limiting as specified.

c. The system shall include a user interface which provides a Graphical User Interface which shall allow for graphical navigation between systems, graphical representations of systems, access to real-time data for systems, ability to override points in a system, and access to all supervisory monitoring and control functions.

d. All software used by the UMCS shall be licensed to and delivered to the installation as specified.

e. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

f. Provide sufficient documentation and data, including rights to documentation and data, such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

g. All communication between the UMCS and building networks shall be via the CEA-709.1-D protocol over the IP network in accordance with CEA-852-C.

1.3.2 Symbols, Definition and Abbreviations

Symbols, definitions, and engineering unit abbreviations used in information displays, submittals and reports shall be as shown in the contract drawings. Symbols, definitions and abbreviations not in the contract drawings shall conform at a minimum to IEEE Stds Dictionary and the ASHRAE FUN SI (ASHRAE FUN IP), as applicable.

1.3.3 System Units and Accuracy

System displays, print-outs and calculations shall be performed in metric (SI) units. Calculations shall have accuracy equal to or exceeding sensor accuracy as specified in Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Displays and printouts shall have precision and resolution equal to or exceeding sensor accuracy as specified in Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

1.3.4 Data Packages/Submittals Requirements

Technical data packages consisting of computer software and technical data (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and shall be delivered with unrestricted rights.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES and TABLE 1: PROJECT SEQUENCING

SD-02 Shop Drawings

UMCS Contractor Design Drawings; G
Draft As-Built Drawings; G
Final As-Built Drawings; G

SD-03 Product Data

Product Data Sheets; G
Computer Software; G

SD-05 Design Data

Network Bandwidth Usage Calculations; G

SD-06 Test Reports

Existing Conditions Report
Factory Test Procedures
Factory Test Report
Start-Up and Start-Up Testing Report
PVT Phase I Procedures
PVT Phase I Report
PVT Phase II Report
Pre-Construction QC Checklist
Post-Construction QC Checklist

SD-10 Operation and Maintenance Data

Preventive Maintenance Work Plan; G
Basic Operator Training Documentation; G
Advanced Operator Training Documentation; G
Operator Refresher Training Documentation; G
Operation and Maintenance (O&M) Instructions; G

SD-11 Closeout Submittals

Closeout QC Checklist; G

1.5 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column).

a. Sequencing for submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon re-submittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	S	Factory Test Procedures	
2	S	Perform Factory Test	AAO #1
3	S	Factory Test Report	30 days ACO #2
4	S	Existing Conditions Report	30 days AAO #3
5	S	Design Drawings	30 days AAO #3
6	S	Product Data Sheets	30 days AAO #3
7	S	Network Bandwidth Calculations	30 days AAO #3
8	S	Pre-construction QC Checklist	30 days AAO #3
9	E	Install UMCS	AAO #4 thru #8
10	E	Start-Up and Start-Up Testing	ACO #9
11	S	Post-Construction QC Checklist	10 days ACO #10
12	S	Computer Software	30 days ACO #10
13	S	Start-Up and Start-Up Testing Report	30 days ACO #10
14	S	Draft As-Built Drawings	30 days ACO #10
15	S	PVT Phase I Procedures	15 days before scheduled start of #16 and AAO #13
16	S	PVT Phase I	AAO #15 and #14
17	S	PVT Phase I Report	15 days ACO #16
18	S	Preventive Maintenance Work Plan	AAO #13
19	S	O&M Instructions	AAO #13
20	S	Basic Operator Training Documentation	AAO #13 and 15 days before scheduled start of #21

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
21	E	Basic Operator Training (PVT Phase II)	AAO #18, #19 and #20
22	S	PVT Phase II Report	15 days ACO #21
23	S	Final As-Built Drawings	15 days AAO #22
24	S	Advanced Operator Training Documentation	15 days before scheduled start of #25 and AAO #20
25	E	Advanced Operator Training	ACO #21, AAO #24, 15 days AAO #24, and no later than 30 days ACO #21
26	S	Operator Refresher Training Documentation	15 days before scheduled start of #27 and AAO #20 and #24
27	E	Operator Refresher Training	ACO #21 and 15 days AAO #26
28	S	Closeout QC Checklist	ACO #25

1.6 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative shall complete the QC Checklist in APPENDIX A, and shall submit the Pre-Construction QC Checklist, Post-Construction QC Checklist, and Closeout QC Checklist as specified. Submit one hard copy & one digital copy (.pdf - text searchable) of the Pre-Construction, Post-Construction, and Closeout QC Checklists. The QC Representative shall verify each item in the Checklists and initial in the provided area to indicate that the requirement has been met. The QC Representative shall sign and date the Checklists prior to submission to the Government.

1.7 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit one hard copy & one digital copy (.pdf - text searchable) of the O&M Instructions. Bound Instructions shall be indexed and tabbed. Instructions in PDF form shall be a single PDF file, or multiple PDF files with a PDF file table of contents containing links to the other files. O&M Instructions may be submitted as a Technical Data Package. The UMCS Operation and Maintenance Instructions shall include:

a. Procedures for the UMCS system start-up, operation and shut-down.

b. Final As-Built drawings.

c. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

d. Qualified service organization list.

e. Start-Up and Start-Up Testing Report.

f. Performance Verification Test (PVT) Procedures and Reports.

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIREMENTS

2.1.1 Product Certifications

Computing devices, as defined in FCC Part 15, supplied as part of the UMCS shall be certified to comply with the requirements of Class B computing devices.

2.1.2 Product Sourcing

Contractor supplied units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and the model and serial number in a conspicuous place. Materials and equipment shall be new standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products.

2.1.3 General Requirements

Provide components that meet the following requirements:

a. Portions of the data communications equipment system installed in unconditioned spaces shall operate properly in an environment with ambient temperatures between -7 and +66 degrees C (+20 and 150 degrees F) and ambient relative humidity between 20% and 95% noncondensing.

b. Components shall accept 100 to 125 volts AC (Vac), 60 Hz, single phase, three wire with a three-pronged, dedicated circuit outlet or be provided with a transformer to meet the component's power requirements.

c. The equipment shall meet the requirements of NFPA 70, UL 60950, NFPA 262, FCC EMC, and FCC Part 15.

2.1.4 Product Data Sheets

For all products (equipment)specified in PART 2 and supplied under this contract, submit copies of all manufacturer catalog cuts and specification sheets for all products (equipment) specified in PART 2 and supplied under this contract, to indicate conformance to product requirements.

2.2 NETWORK HARDWARE

2.2.1 Nameplates

Provide laminated plastic nameplates for all network hardware. Each nameplate shall identify the function, network address and identifier of the device. Laminated plastic shall be 3 mm (0.125 inch) thick, white with black center core. Nameplates shall be a minimum of 25 by 75 mm (1 by 3 inch) with minimum 6 mm (0.25 inch) high engraved block lettering. Attach Nameplates to the device in a conspicuous location.

2.2.2 Building Point of Connection (BPOC) Hardware

2.2.2.1 CEA-709.1-D Gateway

Gateways shall have the appropriate connection on the building-side (non-CEA-709.1-D side) to interface to the building DDC system, and shall meet the following requirements:

a. It shall be capable of being installed, configured and programmed for the designated application and through the use of instructions in the manual supplied by the Contractor.

b. All software required for gateway configuration shall be provided.

c. It shall provide bi-directional protocol translation between the building level control protocol and CEA-709.1-D.

d. It shall allow bi-directional mapping between Standard Network Variable Types (SNVTs) according to the LonMark SNVT List on the CEA-709.1-D side and points on the building control network.

e. It shall communicate on the CEA-709.1-D over an IP network in accordance with CEA-852-C. Contractor may provide a CEA-709.1-D TP/FT-10 to IP Router co-located with the protocol translator to meet this requirement.

f. It shall allow binding of its standard network variables (SNVTs).

g. For the CEA-709.1-D network, it shall be capable of transmitting data using the "min, max, and delta" (throttling and heartbeat) methodology.

h. It shall provide the ability to label SNVTs that are mapped to or from third party devices.

i. It shall provide capacity for mapping all required points as shown plus an additional 10 percent from the legacy side as SNVTs on the CEA-709.1-D side and vice-versa.

j. It shall supply a LonMark external interface file (XIF) as defined in the LonMark XIF Guide for use with LNS tools and utilities.

k. It shall have a "service pin" which, when pressed, will cause the Gateway to broadcast its 48-bit Node ID and Program ID over the network.

l. It shall provide a configurable self-documenting string.

m. It shall retain its configuration after a power loss of an indefinite time, and shall automatically return to its pre-power loss state once power is restored.

2.3 COMPUTER HARDWARE

2.3.1 Nameplates

Provide laminated plastic nameplates for each server and workstation. Each nameplate shall identify the function, network address and identifier of the server or workstation. Laminated plastic shall be 3 mm (0.125 inch) thick, white with black center core. Nameplates shall be a minimum of 25 by 75 mm (1 by 3 inches) with minimum 6 mm (0.25 inch) high engraved block lettering. Attach nameplates to the device in a conspicuous location.

2.3.2 Server Hardware

All computer hardware furnished under this specification shall be standard products of a single manufacturer which advertises service in all 48 contiguous states, and shall be a model currently in production. Server hardware shall meet the following minimum requirements:

a. Processor speed: Minimum 250 percent of the stated requirements of the software to be installed on the server.

b. Random Access Memory (RAM): Minimum 250 percent of the stated requirements of the software to be installed on the server.

c. Communications ports: One serial port, one enhanced parallel port and two USB ports in addition to any ports required for the keyboard and mouse.

d. Hard Drives and Controller: Controller and Drives shall provide at least 500 GB usable disk space with an average seek time of 7 milliseconds or less using hardware RAID (Redundant Array of Inexpensive Disks) at levels 1 or 5 (RAID-1 or RAID-5).

e. CD/DVD-RW Drive: Combo CD-RW with 32x read, 24x write and 16x rewrite and DVD-RW with 12x read; 4x re-write; 2x write.

f. Video output card: Support at least 16 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.

g. Network Interface Card (NIC): Integrated 1000Base-T Ethernet NIC with an RJ45 connector.

h. Monitor: Flat Panel LCD monitor sized as shown but no less than 432 mm (17 inches) (17 inches) with a minimum resolution of 1024 by 768 pixels, non-interlaced, a maximum dot pitch of 0.28 millimeters, and a minimum refresh rate of 70Hz.

i. Keyboard: 101 key keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154.

j. Mouse: 2-button optical scroll mouse with a minimum resolution of 400 dots per inch.

k. Hot-swappable redundant power supplies.

2.3.3 Workstation Hardware (Desktop and Laptop)

Computer Workstation Hardware (workstation) shall be a standard unmodified digital desktop computer of modular design or a laptop as shown. The modular components of the desktop, or the laptop, shall be products of a single manufacturer which advertises service in all 48 contiguous states. Workstations shall meet the following minimum requirements.

a. Processor speed: 150 percent the stated requirements of the software to be installed on the workstation.

b. Random Access Memory (RAM): 150 percent the stated requirements of the software to be installed on the workstation.

c. Communications ports:

(1) Desktop: One serial port and two USB ports in addition to any ports required for the keyboard and mouse.

(2) Laptop: One serial port, one USB port, one PCMCIA card slot, and one additional USB or PS/2 port for a mouse.

d. Hard Drive and controller:

(1) Desktop: 200GB formatted disk space with an average seek time of 7 milliseconds or less.

(2) Laptop: 80GB formatted disk space with an average seek time of 10 milliseconds or less.

e. CD-RW Drive: 24x read; 12x re-write; 24x write. For laptops the CD-RW drive shall be a fixed, modular-bay or external drive.

f. Video output card:

(1) Desktop: Support at least 32 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.

(2) Laptop: Support at least 16 bit color at a minimum resolution of 1024 by 768 at a minimum refresh rate of 60 Hz.

g. Network Interface Card (NIC):

(1) Desktop: Integrated 1000Base-TX Ethernet NIC with an RJ45 connector.

(2) Laptop: Integrated 100Base-TX Ethernet NIC with an RJ45 connector.

h. Monitor:

(1) Desktop: Flat Panel LCD monitor sized as shown but no less than 482 mm (19 inches) (19 inches) with a maximum supported resolution of no less of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 millimeters.

(2) Laptop: LCD Screen sized as shown but no less than 305 mm (12 inches) (12 inches) with a maximum supported resolution of no less than 1024 by 768 pixels

i. Keyboard:

(1) Desktop: 101 key keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154.

(2) Laptop: Standard laptop keyboard.

j. Mouse:

(1) Desktop: 2-button optical scroll mouse with a minimum resolution of 400 dots per inch.

(2) Laptop: Integrated touch-pad.

2.3.4 Printers

Printers shall be local or network printers as shown. Local printers shall have a parallel or USB interface. Network printers shall have a 100Base-T interface with an RJ45 connection and shall have a firmware print spooler compatible with the Operating System print spooler.

2.3.4.1 Alarm Printer

The alarm printer shall use sprocket-fed fanfold paper with adjustable sprockets for paper width up to 279 mm (11 inches). The units shall have programmable control of top-of-form. Printers shall include floor stands with paper racks.

2.3.4.2 Laser Printer

Laser printers shall meet the following minimum requirements:

a. Resolution: 600 by 600 dots per inch.

b. Printing Time: 10 pages per minute.

c. Data Buffer Size: 10 Megabytes.

d. Media Size: ANSI A (216 by 279 mm (8.5 by 11 inches)) and other sizes as shown.

e. Paper Cassette: 250 sheet capacity.

2.3.4.3 Color Printer

The color printer shall use ink jet technology, shall be a full-color printer, and shall meet the following minimum requirements:

a. Resolution: 600 by 600 dots per inch.

b. Printing Time: 2 pages per minute.

c. Data Buffer Size: 16 Megabytes.

d. Colors: Printer shall have a separate replaceable black ink cartridge or print head.

e. Media Type: Paper and transparency film.

f. Media Size: ANSI A (216 by 279 mm (8.5 by 11 inches)) and other sizes as shown.

g. Paper Cassette: 250 sheet capacity.

2.4 COMPUTER SOFTWARE

Submit the most recent versions of all computer software provided under this specification delivered as a Technical Data Package. The user manuals for all software delivered for this project shall be submitted with the software.

2.4.1 Operating System (OS)

The operating system (OS) shall be the latest version of the Army Gold Master Operating System.

2.4.2 Office Automation Software

Office Automation Software shall consist of the e-mail, spreadsheet and word processing portions of the project site's standard office automation software.

2.4.3 Virus Protection Software

Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.

2.4.4 CEA-852-B Configuration Server

The CEA-852-C configuration server shall meet the requirements of CEA-852-C.

2.4.5 CEA-709.1-C Network Configuration Tool

The network configuration tool shall meet the following minimum requirements:

a. It shall solely use LonWorks Network Services (LNS) for all network configuration and management of CEA-709.1-D devices.

b. It shall be capable of executing LNS plug-ins.

c. It shall be capable of performing network database reconstruction of an CEA-709.1-D control network, such that if connected to an existing CEA-709.1-D network it has the ability to query the network and create an LNS database for that network.

d. It shall allow configuration of the network while off-line such that an operator may set up changes to the network while disconnected from the network, and then execute all of them once connected.

e. It shall include the Echelon LNS Report Generator and shall be capable of generating and printing the following reports:

(1) Table containing domain/subnet/node address and node identifier for the entire network or any subset thereof, selected by the user.

(2) Table containing Standard Network Variable (SNVT) input and output details for any CEA-709.1-D device on the network.

(3) Table containing Standard and User-Defined Configuration Properties (SCPTs and UCPTs) for any CEA-709.1-D device on the network.

f. It shall be capable of merging two existing standard LNS databases into a single standard LNS database.

2.4.6 Monitoring and Control (M&C) Software

The monitoring and control (M&C) software shall be an LNS-compatible client-server software package. The software shall accommodate the quantity of points indicated on contract documents and shall be expandable via licensing upgrade to accommodate up to 50,000 points without requiring additional software installation. For the purposes of this requirement a point is a value (SNVT) that the M&C server reads from or writes to the network. The server software shall support clients as specified and shown and shall be expandable via licensing upgrade to support no less than 50 total clients and no less than 20 clients simultaneously without requiring additional server software installation.

2.4.6.1 Passwords

The M&C software shall provide user-based access to M&C functionality. The M&C Software shall obtain user information from the OS or manage M&C user information and shall recognize at least 100 separate users and have at least 4 levels of user permissions. User permission levels (from most restrictive to most permissive) shall include:

a. Permission Level 1: View System Graphic Displays.

b. Permission Level 2: Permission Level 1 plus acknowledge alarms and set up (configure) trends and reports.

c. Permission Level 3: Permission Level 2 plus override SNVTs and set up (configure) alarms, schedules and demand limiting.

d. Permission Level 4: Permission Level 3 plus create and modify System Graphic Displays and create custom programs.

Passwords shall not be displayed. The system shall maintain a disk file logging all activity of the system. If the file format is not plain ASCII text, provide a means to export or convert the file to plain ASCII text. This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. Passwords shall not be logged. The activity log shall be maintained at the server hardware. The system shall automatically provide a mechanism for archiving the log files for long term record storage.

2.4.6.2 Protocol Drivers

The M&C Software shall include a driver to LNS or a driver to the CEA-852-C and shall be capable of reading and writing any SNVT on the CEA-852-C network. The M&C Software may include drivers to other (non-CEA-709.1-D) protocols. The protocol driver shall allow all M&C Software functions to write values to and read values from points on the legacy system. The M&C software shall support reading points from the legacy system and writing these values to SNVTs on the CEA-709.1-D network, and reading SNVTs from the CEA-709.1-D network and writing these values to points on the legacy network. Use of the driver to integrate additional legacy systems shall not require programming but may require configuration.

2.4.6.3 System Graphic Displays

The monitoring and control (M&C) software shall include graphical displays through which an operator can perform real-time access and manipulation of the M&C functions as specified and shown. The graphical displays shall consist of building-level system (air handler units, VAV boxes, chillers, boilers etc) graphic displays, alarm displays, scheduling displays, trending displays, and demand limiting displays. Data associated with an active display shall be updated at least once every 5 seconds.

a. Navigation Scheme: System graphic displays of building-level systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building name and number. Each display shall show system wide data such as outside air temperature and humidity in the case of an HVAC system application.

(1) Each Building or Building Sub-Area display shall show the building foot print and basic floor plan, and shall clearly show and distinguish between the individual zones and the equipment serving each zone and space. The building display shall also show all space sensor and status readings, as applicable, for the individual zones such as space temperature, humidity, occupancy status, etc. The building display shall show the locations of individual pieces of monitored and controlled equipment.

(2) Each equipment display shall show a one-line diagram control schematic representation of the individual pieces of equipment using the symbols and M&C point data types as specified. Different colors and textures shall be used to indicate various components and real time data. Color and texture meanings shall be consistent across all displays.

(3) Each display shall clearly distinguish between the following point data types and information:

(a) Real-time data.

(b) User-entered data.

(c) Overridden or operator-disabled points.

(d) Devices in alarm (unacknowledged).

(e) Out-of-range, bad, or missing data.

b. Navigation Commands: The system graphic displays shall support English language operator commands via point-and-click mouse or keyboard entry for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands shall be usable from any operator workstation with individual operator passwords as specified.

(1) Command Input: Operator's commands shall be full words and acronyms selected to allow operators to use the system without extensive training or any data processing backgrounds. The system shall prompt the operator in full words and acronyms for all required information, identifying acceptable command formats. The operator's response shall be a point-and-click selection, word, phrase, or acronym including parameters where required.

(2) Command Input Errors: The system shall supervise operator inputs to ensure they are correct for proper execution. Operator input assistance shall be provided whenever a command cannot be executed

because of operator input errors. The system shall explain to the operator why the command cannot be executed. Conditions for which operator error assist messages shall be generated include:

(a) The command used is incorrect or incomplete.

(b) The operator is restricted from using that command.

(c) The command addresses an out-of-range or bad data point.

(d) The command addresses a point that does not exist.

(e) The command would violate constraints.

(3) Special Functions: The system shall provide the following point-and-click mouse functions, in addition to all other commands specified:

(a) HELP: shall produce an indexed or menu-driven display of all commands available to the operator. The HELP command, followed by a specific command shall produce a context sensitive listing with a short explanation of the purpose, use, and system reaction to that command.

(b) DISPLAY DIAGRAM: shall display diagrams of specific utility systems or other systems as specified.

(c) DIAGRAM DEVELOPMENT: shall allow the user to develop diagrams of specific utility systems or other systems as specified.

(d) PRINT REPORT: Shall allow the operator to initiate printing of reports.

(4) Operator's Commands: The operator's commands shall provide the means for entry of control and monitoring commands, and for retrieval of information. Processing of operator commands shall commence within 1 second of entry, with some form of acknowledgment provided at that time. The operator's commands shall perform tasks, including:

(a) Request a display of any SNVT or calculated point or any group of related SNVTs and calculated points

(b) Startup and shutdown selected systems or devices.

(c) Override any SNVT point to an operator selected value.

(d) Release the override of a SNVT.

(e) Modify time and event scheduling.

(f) Initiate reports.

(g) Generate and format reports.

(5) System Graphic Display Hierarchy: The system graphic display shall have a hierarchical structure with at least five levels:

(a) Unit: The unit that a point is associated with, such as an

AHU.

(b) Building Sub-Area: A part of a building.

(c) Building: The building that a point is located in or near.

(d) Building Group: A group of buildings.

(e) Facility: Installation included in the UMCS.

c. Display Editor: The display editor shall enable the user to create, modify, and delete displays and graphic symbols. The primary use shall be for adding and modifying one-line diagrams, status displays, system summaries, and system directories, as new controllers, points, data, and other necessary changes are made. The basic functions shall include:

(1) Create and save displays and graphic symbols.

(2) Group and ungroup graphic symbols. The grouped symbol shall be manipulated as a single symbol.

(3) Modify a portion of a graphic symbol.

(4) Save graphic symbols as a library object.

(5) Rotate and mirror a graphic symbol.

(6) Delete a graphic symbol.

(7) Place a graphic symbol on a display.

(8) Cancel the display of a graphic symbol.

(9) Assign conditions which automatically initiate the display.

(10) Overlay alphanumerics and graphics.

(11) Save new, modified, or existing graphics as new graphics.

(12) Integrate real-time data with the display.

(13) Define the background color.

(14) Define the foreground color.

(15) Locate the symbols.

(16) Position and edit alphanumeric descriptors.

(17) Establish connecting lines.

(18) Establish sources of latest data and location of readouts.

(19) Display analog values as specified.

(20) Cursor control (up, down, right, left).

(21) Create and display alphanumeric displays.

(22) Assign graphics a depth such that when there are coincident graphics the one with the lower depth is displayed.

(23) Modify graphic properties based on SNVT values, calculated values or values obtained from a legacy system.

(24) Creating conditional displays such that different graphic symbols or text are displayed based on SNVT values, calculated values or values obtained from a legacy system.

(25) Symbols Library: The library of callable display symbols shall include: Pump, Motor, Two- and Three-way Valves, Flow Sensing Element, Point and Averaging Temperature Sensors, Pressure Sensor, Humidity Sensor, Single and Double Deck Air Handling Unit, Fan, Chiller, Boiler, Air Compressor, Chilled Water Piping, Steam Piping, Hot Water Piping, Ductwork, Unit Heater, Pressure Reducing Valve, Damper, Electric Meter, Limit Switch, Flow Switch, High- and Low- Point and Averaging Temperature Switches, High- and Low- Pressure Switches, Coil, Solenoid Valve, Filter, Condensing Unit, Cooling Tower, Variable Frequency Drive (VFD), Heat Exchanger, Current Sensing Relays. Symbols shall at a minimum conform to ASHRAE FUN SI (ASHRAE FUN IP) where applicable.

2.4.6.4 Scheduling

The M&C software shall be capable of changing the value of any SNVT in the LNS Database and any point available from a connected legacy system via the protocol driver to any legal value according to a schedule. A minimum of 200 user-definable schedules shall be supported and the specified scheduling functions shall be operator accessible and adjustable via graphics display. The M&C software shall reinforce all schedules by transmitting the scheduled value no less than once every 30 minutes. The graphics display shall include the following fields and functions:

a. Current date and time. The OS and M&C software shall automatically make Daylight Savings Time adjustments. Daylight savings time adjustment shall be capable of being disabled by the operator.

b. Building name and number.

c. System identifier and name.

d. System group. Systems shall be capable of being grouped by the user to perform according to a common schedule.

e. Weekly schedules. Each system shall have a weekly schedule based on a seven day per week schedule with independent schedules for each day of the week including no less than 6 value changes per day.

f. Holiday and special event schedules. System scheduling shall support holiday and special event calendar schedules independent of the daily schedule. Special event schedules shall include one-time events and recurring events. Scheduling of one-time events shall include the beginning and ending dates and times of the event. Holiday and special event schedules shall have precedence over device weekly schedules.

2.4.6.5 Alarms

The M&C software shall be capable of generating alarms by comparing SNVT values to user-configurable limits and of handling network variable inputs of type SNVT_Alarm from the control network. The creation of new alarm conditions, the editing of existing alarms conditions, the deletion of existing alarm conditions and all specified alarm functions shall be operator accessible and adjustable via graphics display. M&C Software shall be capable of handling and managing no less than 10,000 alarm points.

a. Alarm Data. Alarm data to be displayed and stored, as applicable and as specified, shall include:

(1) Identification of alarm including building, system (or sub-system), and device name.

(2) Date and time to the nearest second of occurrence.

(3) Alarm type:

(a) Unreliable: Indicates that the source device has failed due to the sensing device or alarm parameter being out-of-range or bad data.

(b) High Alarm.

(c) Low Alarm.

(4) Alarm set point and deadband(if analog).

(5) Engineering units.

(6) Current value or status of the alarm point.

(7) Alarm priority: There shall be two alarm priority levels; critical and informational. Critical alarms shall remain in alarm until acknowledged by an operator and the alarm condition no longer exists; informational alarms shall remain in alarm until the alarm condition no longer exists or until the alarm is acknowledged.

(8) Alarm Message: A unique message with a field of 60 characters shall be provided for each alarm. Assignment of messages to an alarm shall be an operator editable function.

(9) Alarm Secondary Message: Secondary messages shall be assignable by the operator for printing to provide further information, such as telephone lists or maintenance functions, and shall be editable by the operator. The system shall provide for 100 secondary messages, each with 25 lines of 60 characters each.

(10) Acknowledgement status of the alarm and, where acknowledged, the time and date of acknowledgement.

(11) User who acknowledged the alarm.

b. Alarm Notification and Routing: The M&C software shall be capable of performing alarm notification and routing functions. Upon receipt of a network variable of type SNVT_alarm or SNVT_alarm_2 or upon generation of an alarm the M&C software shall immediately perform alarm notification and routing according to an assigned routing for that alarm. The M&C software shall support at least 500 alarm routes; an alarm route shall be a unique combination of any of the following activities:

(1) Generate a pop-up up display on designated workstation monitors. The pop-up display shall include identification of the alarm, date and time of the alarm, alarm message, and current value/status of the alarm point. Alarms shall be capable of being acknowledged from the pop-up display by operators with sufficient permissions. Pop-up displays shall be displayed until acknowledged.

(2) Dial a numeric paging system and leaving a numeric message. The paging system number and numeric message shall be user configurable for each alarm route.

(3) Send an e-mail message via simple mail transfer protocol (SMTP; RFC 821). The e-mail shall contain a scripted message and all alarm data. The e-mail recipient and scripted message shall be user configurable for each alarm route.

(4) Print alarms to designated alarm printers. The printed message shall be the same as the pop-up message.

c. Alarm Display and Acknowledgement. The M&C software shall include an alarm display. A minimum of the most recent 100 system alarms shall be available for display at each workstation as shown, along with all associated alarm data. Alarms shall be capable of being acknowledged from this display. Multiple alarms shall be capable of being acknowledged using a single command. Operator acknowledgment of one alarm shall not automatically be considered as acknowledgment of any other alarm nor shall it inhibit reporting of subsequent alarms.

d. Alarm Storage and Reports: The M&C software shall store each alarm and its associated alarm data to hard disk. The stored data shall be user-sortable and formatted for printing.

2.4.6.6 Trending

The M&C software shall be capable of performing real-time trending on a minimum of 5,000 points simultaneously with a minimum trending capacity of 100 points per second. The M&C software shall be capable of displaying and printing a graphical representation of each trend, and of multiple trended points on the same graph. The software shall be capable of saving trend logs to a file. If the file format is not plain ASCII text in a Comma-Separated-Value (CSV) format, provide a means to export or convert the file to plain ASCII text in a CSV format. Each trend shall be user-configurable for:

a. Point to trend.

b. Sampling interval with a minimum sampling interval no greater than 1 second and a maximum sampling interval no less than 1 hour.

c. Start and Stop Time of Trend: Start and stop times shall be determined by one or more of the following methods:

(1) Start Time and Stop Time

(2) Start Time and Duration

(3) Start Time and number of samples

2.4.6.7 Electrical Power Demand Limiting

The M&C software shall include demand limiting functionality. The demand limiting functionality shall be capable of performing electrical demand limiting such that it can change the occupancy mode or setpoint of DDC Hardware based on a projected demand to maintain demand below a configured target. The demand limiting algorithm shall incorporate priority levels such that low priority equipment is turned off before high-priority equipment. The demand limiting algorithm shall generate a critical alarm when it begins to impact the system and if the demand target is exceeded.

2.4.6.8 Report Generation

Provide software with commands to generate and format reports for displaying on current Workstation, printing, and storing on disk. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator. Dynamic operation of the system shall not be interrupted to generate a report. The report generation mode, either automatic or requested, shall be operator assignable. The report shall contain the time and date when the samples were taken, and the time and date when the report was generated. The software shall be capable of saving reports to a file. If the file format is not in a format compatible with the provided Office Automation Software, provide a means to export or convert the file to a compatible format. Software shall be provided to format and store all data, trends, profiles, reports and logs specified herein in a comma-delimited text format to any media supported by the operating system. The software shall allow for automatic or manual generation of reports. For automatic reports the operator shall be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. The operator shall be able to modify, or inhibit a periodic report. Manual report generation shall allow for the operator to request at any time the output of any report. The software shall have a report generation utility capable of generating the following standard reports:

a. Electrical Power Usage Report: An electrical power Usage summary, operator selectable for substations, meters, or transducers, individual meters and transducers, any group of meters and transducers, and all meters for an operator selected time period. The report shall include the voltage, current, power factor, electrical demand, electrical power consumption, reactive power (Kvar) for each substation, facility, system or equipment as selected by the operator. The report shall be automatically printed at the end of each summary period and shall include:

(1) Total period consumption.

(2) Demand interval peak for the period, with time of occurrence.

(3) Energy consumption (kWh) over each demand interval.

(4) Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.

(5) Reactive power during each demand interval.

(6) Power factor during each demand interval.

(7) Outside air (OA) temperature and relative humidity (RH) taken at the maximum and minimum of OA temperature of the report period with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and RH shall also be recorded.

(8) Calculated heating and cooling degree days based on a 18.3 degrees C (65 degrees F) balance point.

b. Electrical Peak Demand Prediction Report: A report based on the demand limiting program. The report shall include:

(1) Electrical Demand Target (EDT).

(2) Actual peak and predicted peak for each demand interval for that day.

(3) Predicted demand for the next demand interval.

c. Energy usage Report: An energy usage summary, operator selectable, for a unit, building, area, installation, and the entire UMCS. The report shall be divided by utility, and shall be capable of reporting on at least four separate utilities. The report shall include the following information:

(1) Beginning and ending dates and times.

(2) Total energy usage for each utility for the current and previous day.

(3) Total energy usage for each utility for the current and previous month.

(4) Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month.

(5) Outside air (OA) temperature and OA relative humidity (RH) or dew point for current and previous month and current and previous day:

(a) Average temperature and RH or dew point.

(b) Temperature and RH or dew point at maximum and minimum OA temperature with time and date of occurrence.

(b) Temperature and RH or dew point at maximum and minimum RH or dew point with time and date of occurrence.

(c) Temperature and RH or dew point at the installation's peak demand interval with the time and date of occurrence

(6) Calculated degree days.

d. Alarm Report: Outstanding alarms by building or unit, including time of occurrence.

e. Override Report: Points overridden, including time overridden, and identification of operator overriding the point.

f. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able define equipment groupings and shall be able to generate reports based on these groupings.

g. Cooling Tower Profiles: A cooling tower profile for each cooling tower as shown, including:

(1) Total daily and monthly on-time (each fan).

(2) Number of on and off transitions (each fan).

(3) Maximum and minimum daily condenser water temperature and the time of occurrence for the current and previous months.

h. Chiller usage Report: A report of the operation of each chiller as shown on a daily and monthly basis, including:

(1) Daily run-time in each one of at least 10 discrete loading levels.

(2) Total on-time for each level for the current month.

(3) Monthly average energy use in kWh or Mbtu for total on-time at each level.

2.5 UNINTERRUPTIBLE POWER SUPPLY (UPS)

The uninterruptible power supply (UPS) shall be a self contained device suitable for installation and operation at the location of Server and Workstation hardware and shall be sized to provide a minimum of 20 minutes of operation of the connected hardware. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of AC input loss and low battery power. The UPS shall be UL 1778 approved. UPS powering Server Hardware shall support notification to the server via serial or USB interface of impending battery failure.

2.6 RACKS AND ENCLOSURES

2.6.1 Enclosures

Enclosures shall meet the following minimum requirements:

a. Outdoors: Enclosures located outdoors shall meet NEMA 250 Type 3 or Type 4 requirements unless otherwise indicated.

b. Mechanical and Electrical Rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 or Type 4 requirements unless otherwise indicated.

c. Other Locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings, and plenum returns shall meet NEMA 250 Type 1 requirements.

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable. Keys for lockable enclosures shall be furnished.

2.6.2 Equipment Racks

Equipment racks shall be either aluminum or steel with bolted or welded construction. Steel equipment racks shall be painted with a flame-retardant paint. Guard rails shall be included with each equipment rack and have a copper grounding bar installed and grounded to the earth. These equipment racks shall be compatible with the electronic equipment provided.

PART 3 EXECUTION

3.1 FACTORY TEST

Perform factory testing of the UMCS as specified. The Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform required testing. Written notification of planned testing shall be given to the Government at least 21 days prior to testing, and in no case shall notice be given until after the Contractor has received written Government approval of the specific Factory Test Procedures. The Procedures shall define the tests required to ensure that the system meets technical, operational, and performance specifications. Submit one hard copy & one digital copy (.pdf - text searchable) of the Procedures which may be submitted as a Technical Data Package. The Procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. The test procedures shall provide for testing all capabilities and functions specified and shown. The Procedures shall be developed from the design documentation and in accordance with Section 25 08 10, UTILITY MONITORING AND CONTROL SYSTEM TESTING. The Factory Test shall be performed using equipment and software of the same manufacturer, model and revision as will be used by the Contractor for the specified project. Procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. Upon completion of the test, prepare a Factory Test Report, documenting the results of the Test. Submit one hard copy & one digital copy (.pdf - text searchable) of the Factory Test Report which may be submitted as a Technical Data Package.

3.2 EXISTING CONDITIONS SURVEY

Perform a field survey, including but not limited to testing and inspection of equipment to be part of the UMCS, and submit an Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. Submit one hard copy & one digital copy (.pdf - text searchable) of the Existing Conditions Report. Verify the availability of the building network backbone at the BPOC location, and verify that BPOCs shown as furnished are installed at the BPOC location.

3.3 DRAWINGS AND CALCULATIONS

3.3.1 Network Bandwidth Usage Calculations

Perform UMCS Network Bandwidth Usage Calculations for a normally loaded and a heavily loaded UMCS. Submit one hard copy & one digital copy (.pdf - text searchable) of the Network Bandwidth Usage Calculations.

Calculations shall be performed for network traffic at the M&C Server. A heavily loaded network is characterized as one performing the following activities simultaneously:

a. Trending a number of points equal to the specified minimum M&C software trending capacity at 15 minute intervals.

b. Trending (for loop tuning) 20 points at 2 second intervals.

c. Viewing 500 points via workstations with a 5 second update interval.

d. Transmitting load shed commands (via SNVTs) to 2,000 devices in a 1 minute interval.

e. Viewing of 10 system display graphic screens of 50 points each via browsers.

A normally loaded network is characterized as one performing the following activities simultaneously:

a. Trending 500 points equal at 15 minute intervals.

b. Viewing 100 points via workstations with a 5 second update interval.

c. Transmitting load shed commands (via SNVTs) to 200 devices in a 1 minute interval.

e. Viewing of 2 system display graphic screens of 50 points each via browsers.

3.3.2 UMCS Contractor Design Drawings

Revise and update the Contract Drawings to include details of the system design. Submit UMCS Contractor Design Drawings in hard copy and on CDROM in AutoCAD or Microstation format. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Details to be shown on the Design Drawing include:

a. Details on logical structure of the network. This includes logical location of all network hardware.

b. Manufacturer and model number for each piece of computer and network hardware.

c. Physical location for each piece of network or computer hardware.

3.3.3 As-Built Drawings

Prepare Draft As-Built Drawings consisting of Points Schedule drawings for the entire UMCS and an updated Design Drawing including details of the actual installed system as it is at the conclusion of Start-Up and Start-Up Testing. Submit the drawings in hard copy and on CDROM in AutoCAD or Microstation format. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. In addition to the details shown in the design drawings, the as-built drawing shall include:

a. IP address(es) as applicable for each piece of network hardware.

b. IP address for each computer server, workstation and networked printer.

c. Network identifier (name) for each printer, computer server and computer workstation.

d. CEA-709.1-D address (domain, subnet, node address) for each CEA-709.1-D TP/FT-10 to IP Router.

Prepare Draft As-Built Drawings upon the completion of Start-Up and Start-Up Testing and Final As-Built Drawings upon completion of PVT Phase II. Submit Final As-Built Drawings in hard copy and on CDROM in AutoCAD or Microstation format.

3.4 INSTALLATION REQUIREMENTS

3.4.1 General

Install system components as shown and specified and in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Communication equipment and cable grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. Fiber Optic cables and wiring in exposed areas, including low voltage wiring but not including network cable in telecommunication closets, shall be installed in metallic raceways or EMT conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.4.2 Isolation, Building Penetrations and Equipment Clearance

The UMCS shall be completely installed and ready for operation, as specified and shown. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exteriors shall be made watertight. Holes in concrete, brick, steel and wood walls shall be drilled or core drilled with proper equipment; conduits installed through openings shall be sealed with materials which are compatible with existing materials. Openings shall be sealed with materials which meet the requirements of NFPA 70 and SECTION 07 84 00 FIRESTOPPING.

3.5 INSTALLATION OF EQUIPMENT

3.5.1 Wire and Cable Installation

System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with TIA-606. Penetrations in fire-rated construction shall be firestopped in accordance with Section 07 84 00 FIRESTOPPING. Conduits, outlets and raceways shall be installed in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring shall be installed in accordance with TIA-568-C.1 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring, and terminal blocks and outlets shall be marked in accordance with TIA-606. Non fiber-optic cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or raceways shall be properly secured and neat in appearance.

3.5.2 Grounding

Signal distribution system ground shall be installed in accordance with TIA-607 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Equipment racks shall be connected to the electrical safety ground.

3.5.3 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

3.5.4 Computer Hardware and Software

3.5.4.1 Hardware Installation

Computer Hardware shall be installed as shown. Computer Servers shall be powered through a UPS, and shall be installed and configured such that the server will automatically undergo a clean shutdown upon low battery signal from the UPS.

3.5.4.2 Software Installation

Contractor shall install software as follows:

a. CEA-852-C Configuration Server: Install and configure one CEA-852-C Configuration Server. The CEA-852-C Configuration Server shall be installed on Server Hardware, Workstation Hardware, or an CEA-709.1-D TP/FT-10 to IP Router.

b. CEA-709.1-D Network Configuration Tool: Install the network configuration tool software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on workstation or server hardware.

c. Monitoring and Control Software: Install the monitoring and control software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on workstation or server hardware.

d. Operating system: Install the OS on each Server and Workstation and configure user names and passwords.

e. Office Automation Software: Install the office automation software on each server and workstation.

f. Virus Protection software: Install the virus protection software on each server and workstation and configure weekly virus scans.

3.5.5 Building Point of Connection (BPOC) Installation

Provide Building Point of Connection hardware for each building control network to be connected as shown on drawings. BPOC hardware shall be installed in an enclosure or in a lockable enclosure at the BPOC locations as shown on drawings and connected to the Government Furnished network drop. Configure all BPOCs for building control networks to be connected, including those installed under this contract as well as those furnished with the building control networks.

3.5.6 IP Addresses

Coordinate with the NEC to obtain IP addresses for all BPOC hardware.

3.6 INTEGRATION OF BUILDING LEVEL CONTROLS

3.6.1 Integration of CEA-709.1-C Building Control Systems

Perform the following tasks to integrate the building system into the UMCS:

a. Update the UMCS LNS Database. The LNS database shall be updated by merging the building database with the UMCS database. In cases where the building database is not available use the Network Configuration Tool software to discover the building network and create an LNS Database for the building and then merge the building database and the UMCS database.

b. Establish network variable polling or bindings as shown and as necessary to support M&C Software functionality:

(1) SNVTs used for display on currently active displays shall be updated (via polling) as necessary to meet display requirements.

(2) SNVTs used for currently active trends shall be updated (via polling) as necessary to meet trend interval requirements.

(3) SNVTs used for alarms shall be bound using acknowledged service or polled at 5 minute intervals.

(4) SNVTs used for scheduling shall be sent to the appropriate System Scheduler with a maximum time between subsequent transmissions of the SNVT of 30 minutes, shall be of type SNVT_occupancy, and support the following values: OC_OCCUPIED, OC_UNOCCUPIED and OC_STANDBY.

(5) SNVTs used for overrides shall be sent to the device receiving the override using the network variable and SNVT type shown on the Points Schedule. SNVTs for overriding schedules (via the System Scheduler) shall be of type SNVT_occupancy and shall support the following values: OC_OCCUPIED, OC_UNOCCUPIED, OC_STANDBY and OC_NUL. SNVTs used to override schedules or setpoints for Demand Limiting functions shall use the acknowledged service.

c. Configure M&C Software functionality:

(1) Create graphical pages for System Graphic Displays using the project site sample graphic pages, including overrides, as shown on the Points Schedule and as specified. SNVTs for monitoring shall be updated while the monitoring graphic for that SNVT is active. Label all points on graphic pages with the point name and description as shown on the Points Schedule.

(2) Configure alarm generation and alarm handling as shown on the Points Schedule and Alarm Routing Schedules and as specified.

(3) Configure the scheduling function of the M&C software to schedule systems (SNVTs) as shown on the Points Schedule and as specified. Label schedules and scheduled points with full English-language descriptors.

(4) Create trends for required points as shown on the Points Schedule and as specified. Trend points at 15 minute intervals.

(5) Configure Demand Limiting as shown on the Demand Limit Schedule and Points Schedule and as specified.

3.6.2 Integration of Other Building Control Systems via a Gateway

Perform the following tasks when integrating a non-CEA-709.1-D system using a CEA-709.1-D Gateway:

a. Install and configure the CEA-709.1-D Gateway, including adding the gateway to the LNS database and network drawing. The gateway shall be configured such that the required data (points) as shown from the Legacy system can be read as SNVTs on the CEA-709.1-D side of the gateway and that required commands as shown on the legacy side of the gateway can be written as SNVTs on the CEA-709.1-D side of the gateway.

b. When the Gateway performs protocol translation to CEA-709.1-D, an CEA-709.1-D TP/FT-10 to IP Router shall be installed on configured to connect the gateway to the UMCS IP Network.

c. Configure M&C functionality as specified in paragraph Integration of CEA-709.1-D Building Control Systems.

3.6.3 Extending Legacy System Network to the M&C Server

When integrating non-CEA-709.1-D legacy systems at the M&C Server:

a. Extend the legacy system network to the M&C Server

b. Configure the M&C software protocol driver to provide read and write access to required legacy system data as shown.

c. Configure M&C functionality as specified in paragraph Integration of CEA-709.1-D Building Control Systems

3.7 START-UP AND START-UP TESTING

Contractor shall test all equipment and perform all other tests necessary to ensure the system is installed and functioning as specified. Contractor shall prepare a Start-Up and Start-Up Testing Report documenting all tests performed and their results and certifying that the system meets the requirements specified in the contract documents. Submit one hard copy & one digital copy (.pdf - text searchable) of the Report which may be submitted as a Technical Data Package.

3.8 PERFORMANCE VERIFICATION TEST (PVT)

3.8.1 PVT Phase I Procedures

Submit one hard copy & one digital copy (.pdf - text searchable) of the PVT Phase I Procedures. The PVT Procedures may be submitted as a Technical Data Package. PVT Procedures shall include:.

a. Network bandwidth usage and available bandwidth (throughput) measurements. Network bandwidth usage shall reference the normal usage network Bandwidth Calculations.

b. Test System Reaction during PVT: The total system response time from initiation of a control action command from the workstation, to display of the resulting status change on the workstation shall not exceed 20 seconds under system normal heavy load conditions assuming a zero response time for operation of the node's control device.

c. Verification of IP Connectivity.

d. Verification of configuration of M&C Software functionality.

3.8.2 PVT Phase I

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, demonstrate all physical and functional requirements of the project. Upon completion of PVT Phase I and as specified, prepare and submit the PVT Phase I Report documenting all tests performed during the PVT and their results. Submit one hard copy & one digital copy (.pdf - text searchable) of the PVT Phase I Report which may be submitted as a Technical Data Package. The PVT report shall include all tests in the PVT Procedures and any other testing performed during the PVT. Failures and repairs shall be documented with test results.

3.8.3 PVT Phase II

PVT Phase II shall consist of Basic Operator Training. Failures or deficiencies of the UMCS during Basic Operator Training shall be considered PVT failures. Upon completion of PVT Phase II, and as specified, prepare the PVT Phase II Report documenting any failures which occurred and repairs performed during PVT Phase II. Submit one hard copy & one digital copy (.pdf - text searchable) copies of the PVT Phase II Report which may be submitted as a Technical Data Package.

3.9 MAINTENANCE AND SERVICE

Perform inspection, testing, cleaning, and part or component replacement as specified and as required to maintain the warranty. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the UMCS operating as specified, and accepted by the Government, and other services as specified. Work shall comply with manufacturer's recommendations and industry standards. Provide technical support via telephone during regular working hours.

3.9.1 Work Coordination

Schedule and arrange work to cause the least interference with the normal Government business and mission. In those cases where some interference may be essentially unavoidable, coordinate with the Government to minimize the impact of the interference, inconvenience, equipment downtime, interrupted service and personnel discomfort.

3.9.2 Work Control

When the Contractor completes work on a system or piece of equipment, that system or piece of equipment shall be free of missing components or defects which would prevent it from functioning as originally intended and designed. Replacements shall conform to the same specifications as the original equipment. During and at completion of work, debris shall not be allowed to spread unnecessarily into adjacent areas nor accumulate in the work area itself.

3.9.3 Working Hours

Working hours are from 7:30 A.M. to 4:00 P.M. local time Mondays through Fridays except Federal holidays.

3.9.4 Equipment Repairs

Equipment repairs shall be initiated and completed within the following time periods. Time periods shall be measured as actual elapsed time from first notification, including working and non-working hours:

a) for non-redundant computer server hardware, initiate within 4 hours and complete within 8 hours.

b) for non-redundant computer workstation hardware, initiate within 4 hours and complete within 8 hours.

c) for redundant computer server hardware, initiate within 36 hours and complete within 5 days.

d) for redundant computer workstation hardware, initiate within 2 days and complete within 5 days.

e) for active (powered) network hardware, initiate within 4 hours and complete within 6 hours.

f) for cabling and other passive network hardware, initiate within 16 hours and complete within 5 days.

Repair is the restoration of a piece of equipment, a system, or a facility to such condition that it may be effectively used for its designated purposes. Repair may be overhaul, reprocessing, or replacement of nonfunctional parts or materials or replacement of the entire unit or system.

3.9.5 Replacement, Modernization, Renovation

The Government may replace, renovate, or install new equipment at Government expense and by means not associated with this contract. Replaced, improved, updated, modernized, or renovated systems and equipment interfaced to the system may be added to the Contractor's maintenance and service effort as a modification.

3.9.6 Access To UMCS Equipment

Access shall be in accordance with the following:

a. Coordinate access to facilities and arrange that they be opened and closed during and after the accomplishment of the work effort. For access to a controlled facility contact the Government for assistance.

b. The Government may provide keys for access to UMCS equipment where the Government determines such key issuance is appropriate. Establish and implement methods of ensuring that keys issued by the Government are not lost or misplaced, are not used by unauthorized persons, and are not duplicated.

c. The Government may provide passwords for access to UMCS computer equipment where the Government determines such password issuance is appropriate. Establish and implement methods of ensuring that passwords issued by the Government are not used by unauthorized persons.

3.9.7 Records, Logs, and Progress Reports

Keep records and logs of each task, and organize cumulative chronological records for each major component, and for the complete system. Maintain a continuous log for the UMCS. Keep complete logs and be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the UMCS.

3.9.8 Preventive Maintenance Requirements

Perform maintenance procedures as described below, or more often if required by the equipment manufacturer.

3.9.8.1 Preventive Maintenance Work Plan

Prepare a Preventive Maintenance Work Plan detailing and scheduling all required preventive maintenance. Submit one hard copy & one digital copy (.pdf - text searchable) of the Work Plan which may be submitted as a Technical Data Package. Government approval of the Work Plan shall be obtained as specified in paragraph PROJECT SEQUENCING. Strictly adhere to the approved work plan to facilitate Government verification of work. If it is necessary to reschedule maintenance, make a written request to the Government detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates will be changed only with the prior written approval of the Government.

3.9.8.2 Semiannual Maintenance

Contractor shall perform the following Semiannual Maintenance as specified:

a. Perform data backups on all Server Hardware.

b. Run system diagnostics and correct diagnosed problems.

c. Perform fan checks and filter changes for UMCS hardware.

d. Perform all necessary adjustments on printers.

e. Resolve all outstanding problems.

f. Install new ribbons, ink cartridges and toner cartridges into printers, and ensure that there is at least one spare ribbon or cartridge located at each printer.

3.9.8.3 Maintenance Procedures

a. Maintenance Coordination: Any scheduled maintenance event that will result in component downtime shall be coordinated with the Government as follows. Time periods shall be measured as actual elapsed time from beginning of equipment off-line period, including working and non-working hours.

(1) For non-redundant computer server hardware, provide 14days notice, components shall be off-line for no more than 8 hours.

(2) For non-redundant computer workstation hardware, provide 7 days notice, components shall be off-line for no more than 8 hours.

(3) for redundant computer server hardware, provide 7 days notice, components shall be off-line for no more than 36 hours.

(4) For redundant computer workstation hardware, provide 4 days notice, components shall be off-line for no more than 48 hours.

(5) For active (powered) network hardware, provide 14 days notice, components shall be off-line for no more than 6 hours.

(6) For cabling and other passive network hardware, provide 21 days notice, components shall be off-line for no more than 12 hours.

b. Software/Firmware: Software/firmware maintenance shall include operating systems, application programs, and files required for the proper operation of the UMCS regardless of storage medium. User (project site) developed software is not covered by this contract, except that the UMCS software/firmware shall be maintained to allow user creation, modification, deletion, and proper execution of such user-developed software as specified. Perform diagnostics and corrective reprogramming as required to maintain total UMCS operations as specified. Back up software before performing any computer hardware and software maintenance. Do not modify any parameters without approval from the Government. Properly document any approved changes and additions, and update the appropriate manuals.

c. Network: Network maintenance shall include testing transmission media and equipment to verify signal levels, system data rates, errors and overall system performance.

3.9.9 Service Call Reception

a. A Government representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the Government.

b. Submit procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays. A single telephone number shall be provided by the Contractor for receipt of service calls during regular working hours. Service calls shall be considered received by the Contractor at the time and date the telephone call is placed by the authorized Government representative.

c. Separately record each service call request, as received on the Service Call Work Authorization form and complete the Service Call Work Authorization form for each service call. The completed form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.

d. Respond to each service call request within two working hours. The status of any item of work must be provided within four hours of the inquiry during regular working hours, and within 16 hours after regular working hours or as needed to meet the Equipment Repair requirements as specified.

3.9.10 Service Call Work Warranty

Provide a 1 year unconditional warranty on service call work. The warranty shall include labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event that Contractor service call work causes damage to additional equipment, the Contractor is liable for labor and material to restore the system to full operation. Contractor response to service call warranty work shall be the same as required by the initial service call.

3.9.11 System Modifications

Make recommendations for system modification in writing to the Government. No system modifications shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected. Make available to the Government software updates for all software furnished under this specification during the life of this contract. There shall be at least one scheduled update near the end of the contract period, at which time make available the latest released version of all software provided under this specification, and install and validate it upon approval by the Government.

3.10 TRAINING

Conduct training courses for designated personnel in the maintenance, service, and operation of the system as specified, including specified hardware and software. The training shall be oriented to the specific system provided under this contract. The Contractor is responsible for providing audiovisual equipment and other training material and supplies. When training is conducted at Government facilities, the Government reserves the right to record the training sessions for later use. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor should assume that attendees will be tradesmen such as electricians or boiler operators. Approval of the Contractor's training schedule shall be obtained from the Government at least 30 days prior to the first day of training.

3.10.1 Training Documentation

Prepare and submit one set of Training manuals for each of Basic Operator Training Documentation, Advanced Operator Training Documentation, and Operator Refresher Training Documentation. Documentation shall consist of: :

a. Submit Training manuals for Basic Operator Training delivered for each trainee on the Course Attendance List with one additional hard copy & one additional digital copy (.pdf - text searchable) delivered for archival at the project site. One hard copy & one digital copy (.pdf

- text searchable) of the Course Attendance List shall be delivered with the archival copies. The Basic Operator Training Documentation may be submitted as a Technical Data Package.

b. Submit one set of training manuals delivered for each trainee on the Course Attendance List with one additional hard copy & one additional digital copy (.pdf - text searchable) delivered for archival at the project site. One hard copy & one digital copy (.pdf - text searchable) of the Course Attendance List shall be delivered with the archival copies. The Advanced Operator Training Documentation may be submitted as a Technical Data Package.

c. Submit one set of training manuals delivered for each trainee on the Course Attendance List with one additional hard copy & one additional digital copy (.pdf - text searchable) delivered for archival at the project site. One hard copy & one digital copy (.pdf - text searchable) of the Course Attendance List shall be delivered with the archival copies. The Operator Refresher Training Documentation may be submitted as a Technical Data Package.

d. Course attendance list: A list of course attendees shall be developed in coordination with and signed by the Controls, HVAC, or Electrical shop supervisor.

e. Training Manuals: Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals.

3.10.2 Basic Operator Training

The Basic Operator Training course shall be taught at the project site on the installed system for a period of no less than 5 training days during Phase 2 of the PVT. A maximum of ten personnel will attend this course. This training shall be targeted towards training personnel in the day-to-day operation and basic maintenance of the system. Upon completion of this course, each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware architecture and operation of the system. This course shall at a minimum include:

a. General system architecture.

b. Functional operation of the system, including workstations and system navigation.

c. System start-up procedures.

d. Failure recovery procedures.

e. Schedule configuration.

f. Trend configuration.

g. Perform point overrides and override release.

h. Reports generation.

i. Alarm reporting and acknowledgements.

j. Diagnostics.

k. Historical files.

l. Maintenance procedures:

(1) Physical layout of each piece of hardware.

(2) Troubleshooting and diagnostic procedures.

(3) Preventive maintenance procedures and schedules.

3.10.3 Advanced Operator Training

The advanced operator course shall be taught off-site or at the project site for a period of not less than five days. A maximum of ten personnel will attend this course. The course shall consist of "hands-on" training under the constant monitoring of the instructor. Advanced Operator Training shall include training on the M&C Software and the CEA-709.1-D Network Configuration Tool. Upon completion of this course, the students should be fully proficient in the operation and management of all system operations. Report the skill level of each student at the end of this course. This course shall at minimum include:

a. A review of all topics in Basic Operator Training

b. CEA-709.1-D Network Management

c. M&C Software Graphic Generation

3.10.4 Operator Refresher Training

The refresher course shall be taught at the project site for a period of two training days when approved by the Government and as specified in paragraph PROJECT SEQUENCING. A maximum of ten personnel will attend the course. The course shall be structured to address specific topics that the students need to discuss and to answer questions concerning the operation of the system. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed UMCS. Any system failures discovered during the Operator Refresher Training shall be corrected by the Contractor at no cost to the Government.

APPENDIX A

QC CHECKLIST

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

This checklist is for (check one:)

Pre-Construction QC Checklist Submittal (Items 1-3)	|____|
Post-Construction QC Checklist Submittal (Items 1-6)	|____|
Close-out QC Checklist Submittal (Items 1-14)	|____|

Initial each item in the space provided (|____|) verifying that requirement has been met.

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklists Submittal:

1	Network bandwidth calculations have been performed and indicate that the UMCS will meet network bandwidth requirements.	|____|
2	Contractor Design Drawing Riser Diagram includes location and types of Building Point Of Connection (BPOC) Hardware.	|____|
3	M&C Software is LonWorks Network Services (LNS) based and uses LNS for interfacing to CEA-709.1-D networks.	|____|

Items verified for Post-Construction and Closeout QC Checklist Submittal:

4	Connections between the UMCS IP network and CEA-709.1-D building networks are through CEA-709.1-D TP/FT-10 to IP Routers.	|____|
5	Computer workstations and servers are installed as shown on the UMCS Riser Diagram.	|____|
6	Training schedule and course attendee lists have been developed and coordinated with shops and submitted.	|____|

Items verified for Closeout QC Checklists Submittal:

7	LNS Database is up-to-date and accurately represents the final installed system	|____|
8	All software has been licensed to the Government	|____|
9	M&C software monitoring displays have been created for all building systems, including all override and display points indicated on Points Schedule drawings.	|____|
10	Final As-built Drawings accurately represent the final installed system.	|____|
11	Default trends have been set up (per Points Schedule drawings)	|____|

QC CHECKLIST

12	M&C Software schedules have been set up (per Occupancy Schedule drawing).	|____|
13	O&M Instructions have been completed and submitted.	|____|
14	Basic Operator and Advanced Operator Training courses have been completed	|____|

____

(QC Representative Signature) (Date)

-- End of Section --

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

1.2 RELATED REQUIREMENTS

This section applies to certain sections of Division 02, EXISTING CONDITIONS Division 11, EQUIPMENT, Division 13, SPECIAL CONSTRUCTION, and Divisions 22 and 23, PLUMBING and HEATING VENTILATING AND AIR CONDITIONING. This section applies to all sections of Division 26, 27, 28 and 33, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections. This section has been incorporated into, and thus, does not apply to, and is not referenced in the following sections.
Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM
Section 26 23 00 SWITCHBOARDS AND SWITCHGEAR
Section 26 51 00 INTERIOR LIGHTING

Section 26 56 00 EXTERIOR LIGHTING
Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics shall be as indicated on the drawings. Final connections to the power distribution system shall be made by the Contractor as directed by the Contracting Officer.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.9 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.10 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

1.11 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers and pad-mounted SF6 switches, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 178 by 255 mm (7 by 10 inches) with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 50 mm (2 inch) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 355 by 255 mm (14 by 10 inches) with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 75 mm (3 inch) high white letters on a red and black field.

1.12 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.13 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications.

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements specified in the technical sections.

PART 3 EXECUTION

3.1 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in the section specifying the associated electrical equipment.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 9 meters (30 feet) apart.

-- End of Section --

SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2011) Steel Construction Manual

ASTM INTERNATIONAL (ASTM)

ASTM E580/E580M	(2014) Application of Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels in Areas Requiring Moderate Seismic Restraint

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1598	(2008; Reprint Oct 2012) Luminaires

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below. Structural requirements shall be in accordance with Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.2.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of these specifications:

Control Panels	Switchgear
Pumps with Motors	Unit Substations
Light Fixtures	Transformers
Motor Control Centers	Storage Racks
Switchboards (Floor Mounted)	

1.2.3 Electrical Systems

Electrical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification.

1.2.4 Contractor Designed Bracing

Submit copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-310-04 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-310-04 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-310-04 are based on strength design; therefore, AISC 325 shall be used for the design. The bracing for the following electrical equipment and systems shall be developed by the Contractor.

1.2.5 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 64 mm (2-1/2 inches) trade size. All other interior conduits shall be seismically protected as specified.

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail, indicating thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction. Submit copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment and other items as indicated on drawings to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04. Each item of rigid electrical equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Engine-Generators
Substations
Transformers
Switch Boards and Switch Gears
Motor Control Centers
Free Standing Electric Motors

1.3.2 Nonrigid or Flexibly-Mounted Equipment

The items of equipment indicated on the drawings shall be constructed and assembled to resist a horizontal lateral force of .1 times the operating weight of the equipment at the vertical center of gravity of the equipment.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting Fixtures in Buildings
Equipment Requirements

SD-03 Product Data

Lighting Fixtures in Buildings; G
Equipment Requirements; G
Contractor Designed Bracing; G

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Lighting fixtures and supports shall conform to UL 1598.

2.2 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Conduit shall be braced as for an equivalent weight pipe in accordance with Section 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.

3.2 LIGHTING FIXTURES IN BUILDINGS

Lighting fixtures and supports shall conform to the following:

3.2.1 Pendant Fixtures

Pendant fixtures shall conform to the requirements of UFC 3-310-04.

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fluorescent Fixtures

Recessed fluorescent individual or continuous-row mounted fixtures shall be supported by a seismic-resistant suspended ceiling support system built in accordance with ASTM E580/E580M. Seismic protection for the fixtures shall conform to the requirements of UFC 3-310-04. Recessed lighting fixtures not over 25 kg (56 pounds) in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Fixture accessories, including louvers, diffusers, and lenses shall have lock or screw attachments.

3.2.2.2 Surface-Mounted Fluorescent Fixtures

Surface-mounted fluorescent individual or continuous-row fixtures shall be attached to a seismic-resistant ceiling support system built in accordance with ASTM E580/E580M. Seismic protection for the fixtures shall conform to the requirements of UFC 3-310-04.

3.2.3 Assembly Mounted on Outlet Box

A supporting assembly, that is intended to be mounted on an outlet box, shall be designed to accommodate mounting features on 100 or 75 mm (4 or 3 inch) boxes, plaster rings, and fixture studs.

3.2.4 Wall-Mounted Emergency Light Unit

Attachments for wall-mounted emergency light units shall be designed and secured for the worst expected seismic disturbance at the site.

3.2.5 Lateral Force

Structural requirements for light fixture bracing shall be in accordance with Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

-- End of Section --

SECTION 26 08 00

APPARATUS INSPECTION AND TESTING
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Acceptance tests and inspections

SD-07 Certificates

Qualifications of organization, and lead engineering technician; G

Acceptance test and inspections procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

a. Submit name and qualifications of organization. Organization shall have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization shall have a calibration program, and test instruments used shall be calibrated in accordance with NETA ATS.

b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments shall be performed by an engineering technician, certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

Submit certified copies of inspection reports and test reports. Reports shall include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

1.4.3 Acceptance Test and Inspections Procedure

Submit test procedure reports for each item of equipment to be field tested at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

Testing organization shall perform acceptance tests and inspections. Test methods, procedures, and test values shall be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph entitled "Field Quality Control" of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Equipment shall be placed in service only after completion of required tests and evaluation of the test results has been completed. Contractor shall supply to the testing organization complete sets of shop drawings, settings of adjustable devices, and other information necessary for an accurate test and inspection of the system prior to the performance of any final testing. Contracting Officer shall be notified at least 14 days in advance of when tests will be conducted by the testing organization. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND

b. Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION

c. Section 26 23 00 SWITCHBOARDS AND SWITCHGEAR

3.2 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

3.3 PLACING EQUIPMENT IN SERVICE

A representative of the approved testing organization shall be present when equipment tested by the organization is initially energized and placed in service.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.7	(2005) Requirements for Watthour Meter Sockets
ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2005) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2005) American National Standard for

	Electrical Rigid Aluminum Conduit
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2010) Terminal Blocks
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2014) Motors and Generators
NEMA MG 10	(2013) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2013) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers
NEMA VE 1	(2009) Standard for Metal Cable Tray Systems

NEMA WD 1	(1999; R 2005; R 2010) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2012) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011) American National Standard for Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 70E	(2015) Standard for Electrical Safety in the Workplace
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-569	(2012c; Addendum 1 2013; Errata 2013) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-607	(2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jul 2012) Standard for Flexible Metal Conduit
UL 1063	(2006; Reprint Jul 2012) Machine-Tool Wires and Cables
UL 1203	(2013) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel

UL 1449	(2014) Surge Protective Devices
UL 1561	(2011; Reprint Sep 2012) Dry-Type General Purpose and Power Transformers
UL 1569	(2014) Standard for Metal-Clad Cables
UL 1660	(2014) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2006; Reprint Nov 2013) Arc-Fault Circuit-Interrupters
UL 198M	(2003; Reprint Feb 2013) Standard for Mine-Duty Fuses
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 360	(2013; Reprint Aug 2014) Liquid-Tight Flexible Steel Conduit
UL 4	(2004; Reprint Oct 2013) Standard for Armored Cable
UL 4248-1	(2007; Reprint Oct 2013) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 44	(2014; Reprint Jun 2014) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 486C	(2013; Reprint Feb 2014) Splicing Wire Connectors
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 498	(2012; Reprint Oct 2014) Attachment Plugs and Receptacles
UL 5	(2011) Surface Metal Raceways and Fittings
UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 506	(2008; Reprint Oct 2013) Specialty

	Transformers
UL 508	(1999; Reprint Oct 2013) Industrial Control Equipment
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 514C	(2014) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 5A	(2003; Reprint Jun 2013) Nonmetallic Surface Raceways and Fittings
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 67	(2009; Reprint Nov 2014) Standard for Panelboards
UL 674	(2011; Reprint Jul 2013) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 6A	(2008; Reprint Nov 2014) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 719	(2006; Reprint Apr 2013) Nonmetallic-Sheathed Cables
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 817	(2001; Reprint Jul 2014) Standard for Cord Sets and Power-Supply Cords
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 845	(2005; Reprint Jul 2011) Motor Control Centers
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables
UL 857	(2009; Reprint Dec 2011) Busways
UL 869A	(2006) Reference Standard for Service

	Equipment
UL 870	(2008; Reprint Feb 2013) Standard for Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2006; Reprint Jun 2012) Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 8401	(2010) Rigid Steel Conduits
KS C 8422	(2010) Flexible Metal Conduit
KS C 8431	(2009) Rigid Unplasticized Polyvinyl Chloride (UPVC) Conduits
KS C 8433	(2010) Couplings (for Rigid PVC Conduit Tubes)
KS C 8434	(2010) Connectors (for Rigid PVC Conduit Tubes
KS C 8458	(2012) Boxes and Box Cover for Rigid Metal Conduits
KS C 8459	(2010) Fittings for Flexible Metal Conduits
KS C 8460	(2010) Fittings for Rigid Metal Conduits
KS C 8461	(2010) Surface Accessory for Rigid Metal Conduits
KS C 8464	(2009) Cable Tray

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Motor control centers

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

SD-03 Product Data

Transformers; G
Motor controllers; G
Metering
CATV outlets
Surge protective devices

Submittals shall include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test

Grounding system test

Transformer tests

SD-09 Manufacturer's Field Reports

Transformer factory tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5

Metering, Data Package 5

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein.

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Electrical Systems

Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. This shall include:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.6 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 SEISMIC REQUIREMENTS

Seismic details shall conform to Section 13 48 00, SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and to Section 26 05 48.00 10, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials, equipment, and devices shall, as a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70.

2.2 CONDUIT AND FITTINGS

Shall conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6, or KS C 8401.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2, UL 651, or KS C 8431.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242 or KS C 8401, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40, 1 mm (40 mils) thick.

2.2.6 Flexible Metal Conduit

UL 1 or KS C 8422.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B, KS C 8422, KS C 8459, KS C 8460, or KS C 8461. Ferrous fittings shall be cadmium- or zinc-coated in accordance with UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B, KS C 8431, KS C 8433, or KS C 8434.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

UL 5 or KS C 8461, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Receptacles shall be as specified herein and shall be spaced minimum of one every 455 mm (18 inches).

2.3.2 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Receptacles shall be as specified herein and shall be spaced minimum of one every 455 mm (18 inches).

2.4 BUSWAY

NEMA BU 1.1, UL 857. Buses shall be copper. Busways shall be rated as indicated on drawings. Short circuit rating shall be as indicated. Enclosures shall be steel. Hardware shall be plated or otherwise protected to resist corrosion. Joints shall be one-bolt type with through-bolts, which can be checked for tightness without deenergizing system. Maximum hot spot temperature rise at any point in busway at continuous rated load shall not exceed 55 degrees C above maximum ambient temperature of 40 degrees C in any position. Provide internal barriers to prevent movement of superheated gases. Contractor shall coordinate proper voltage phasing of entire bus duct system, for example where busway interfaces with transformers, switchgear, switchboards, motor control centers, and other system components.

2.4.1 Feeder Busways

Provide ventilated, except that vertical busways within 1830 mm (6 feet) of floors shall be unventilated, low-impedance busway. Bus bars shall be fully covered with insulating material, except at stabs. Entire busway system shall be polarized.

2.4.2 Plug-In Busways

Unventilated type. Plug-in units shall be handle-operated, switch type, equipped with high interrupting-capacity, current-limiting fuses. Bus bars shall be covered with insulating material throughout, except at joints and other connection points. A hook stick of suitable length shall be provided for operating plug-in units from the floor.

2.5 CABLE TRAYS

NEMA VE 1 or KS C 8464. Cable trays shall form a wireway system, and shall be of nominal depth as indicated. Cable trays shall be constructed of steel that has been zinc-coated after fabrication. Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. Radius of bends shall be as indicated.

2.5.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 50 by 100 mm (2 by 4 inch).

2.5.2 Trough-Type Cable Trays

Provide size as indicated.

2.5.3 Ladder-Type Cable Trays

Provide size as indicated.

2.5.4 Channel-Type Cable Trays

Provide size as indicated. Trays shall be one-piece construction having slots spaced not more than 115 mm (4 1/2 inches) on centers.

2.5.5 Solid Bottom-Type Cable Trays

Provide size as indicated. Solid covers shall be provided.

2.5.6 Cantilever

Cantilever-type, center-hung cable trays may be provided at the Contractor's option in lieu of other cable tray types specified.

2.6 OPEN TELECOMMUNICATIONS CABLE SUPPORT

2.6.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Open top cable supports shall be galvanized steel.

2.6.2 Closed Ring Cable Supports

Provide closed ring cable supports in accordance with UL 2043. Closed ring cable supports shall be galvanized steel.

2.7 OUTLET BOXES AND COVERS

UL 514A or KS C 8458, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.7.1 Floor Outlet Boxes

Boxes shall be adjustable and concrete tight. Each outlet shall consist of nonmetallic or cast-metal body with threaded openings, or sheet-steel body with knockouts for conduits, adjustable , brass flange ring, and cover plate with 19 mm (3/4 inch) threaded plug. Telecommunications outlets shall consist of flush, aluminum or stainless steel housing with a receptacle as specified and 19 mm (3/4 inch) top opening. Receptacle outlets shall consist of flush aluminum or stainless steel housing with duplex-type receptacle as specified herein. Provide gaskets where necessary to ensure watertight installation. Provide plugs with installation instructions to the Contracting Officer for 5 percent of outlet boxes for the capping of outlets upon removal of service fittings.

2.7.2 Outlet Boxes for Telecommunications System

Provide standard type 120 mm square by 54 mm deep (4 11/16 inches square by 2 1/8 inches deep). Outlet boxes for wall-mounted telecommunications outlets shall be 100 by 54 by 54 mm (4 by 2 1/8 by 2 1/8 inches) deep. Depth of boxes shall be large enough to allow manufacturers' recommended conductor bend radii. Outlet boxes for fiber optic telecommunication outlets shall include a minimum 10 mm (3/8 inch) deep single or two gang plaster ring as shown and installed using a minimum 27 mm (1 inch) conduit system. Outlet boxes for handicapped telecommunications station shall be 100 by 54 by 54 mm (4 by 2 1/8 by 2 1/8 inches) deep.

2.7.3 Clock Outlet for Use in Other Than Wired Clock System

Provide outlet box with plastic cover, where required, and single receptacle with clock outlet plate. Receptacle shall be recessed sufficiently within box to allow complete insertion of standard cap, flush with plate. Suitable clip or support for hanging clock shall be secured to top plate. Material and finish of plate shall be as specified in paragraph DEVICE PLATES of this section.

2.8 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 1640 mL (100 cubic inches), UL 50, hot-dip, zinc-coated, if sheet steel.

2.9 WIRES AND CABLES

Wires and cables shall meet applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Wires and cables manufactured more than 12 months prior to date of delivery to site shall not be used.

2.9.1 Conductors

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and capacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.9.1.1 Minimum Conductor Sizes

Minimum size for branch circuits shall be No. 12 AWG; for Class 1 remote-control and signal circuits, No. 14 AWG; for Class 2 low-energy, remote-control and signal circuits, No. 16 AWG; and for Class 3 low-energy, remote-control, alarm and signal circuits, No. 22 AWG.

2.9.2 Color Coding

Provide for service, feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows:

a. 208/120 volt, three-phase

   (1) Phase A - black

   (2) Phase B - red

   (3) Phase C - blue

b. 480/277 volt, three-phase

   (1) Phase A - brown

   (2) Phase B - orange

   (3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

d. On three-phase, four-wire delta system, high leg shall be orange, as required by NFPA 70.

2.9.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits shall be Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.9.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.9.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607. The TBB shall be a minimum No. 6 AWG and be sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.

2.9.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding bus bar (TMGB) and the electrical service ground in accordance with TIA-607. The bonding conductor for telecommunications shall be sized the same as the TBB.

2.9.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.9.6 Nonmetallic Sheathed Cable

UL 719, Type NM or NMC.

2.9.7 Wire and Cable for 400 Hertz (Hz) Circuits

Insulated copper conductors.

2.9.8 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

2.9.9 Armored Cable

UL 4; NFPA 70, Type AC cable.

2.9.10 Mineral-Insulated, Metal-Sheathed Cable

UL listed; NFPA 70, Type MI cable. Sheathing containing asbestos fibers shall not be used.

2.9.11 Flat Conductor Cable

UL listed; NFPA 70, Type FCC.

2.9.12 Cable Tray Cable or Power Limited Tray Cable

UL listed; type TC or PLTC.

2.9.13 Cord Sets and Power-Supply Cords

UL 817.

2.10 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires shall be insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.11 DEVICE PLATES

Provide UL listed, one-piece device plates for outlets to suit the devices installed. For metal outlet boxes, plates on unfinished walls shall be of zinc-coated sheet steel or cast metal having round or beveled edges. For nonmetallic boxes and fittings, other suitable plates may be provided. Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.792 mm (0.03 inch) thick. Screws shall be machine-type with countersunk heads in color to match finish of plate. Sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed and UL listed for "wet locations." Device plates in areas normally accessible to prisoners shall be brown or ivory finish nylon-device plates rated for high abuse. Test device plates for compliance with UL 514A and UL 514C for physical strength. Attach device plates with spanner head bolts.

2.12 SWITCHES

2.12.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, and four-way, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Handles shall be brown thermoplastic. Wiring terminals shall be screw-type, side-wired or of the solderless pressure type having suitable conductor-release arrangement. Contacts shall be silver-cadmium and contact arm shall be one-piece copper alloy. Switches shall be rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.12.2 Switch with Red Pilot Handle

NEMA WD 1. Provide pilot lights that are integrally constructed as a part of the switch's handle. The pilot light shall be red and shall illuminate whenever the switch is closed or "on". The pilot lighted switch shall be rated 20 amps and 120 volts or 277 volts as indicated. Provide the circuit's neutral conductor to each switch with a pilot light.

2.12.3 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.12.4 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Fused switches shall utilize Class R fuseholders and fuses, unless indicated otherwise. Switches serving as motor-disconnect means shall be horsepower rated. Provide switches in NEMA 1 or 3R enclosure as indicated per NEMA ICS 6.

2.13 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch or control center. Time-current characteristics curves of fuses serving motors or connected in series with circuit breakers or other circuit protective devices shall be coordinated for proper operation. Submit coordination data for approval. Fuses shall have voltage rating not less than circuit voltage.

2.13.1 Fuseholders

Provide in accordance with UL 4248-1.

2.13.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 198M, Class RK-1 or RK-5, time-delay type. Associated fuseholders shall be Class R only.

2.13.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.13.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.14 RECEPTACLES

UL 498, hard use, heavy-duty, or UL 498, hospital grade, grounding-type. Ratings and configurations shall be as indicated. Bodies shall be of brown as per NEMA WD 1. Face and body shall be thermoplastic supported on a metal mounting strap. Dimensional requirements shall be per NEMA WD 6. Provide screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement. Connect grounding pole to mounting strap. The receptacle shall contain triple-wipe power contacts and double or triple-wipe ground contacts.

2.14.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle shall be switched when installed.

2.14.2 Weatherproof Receptacles

Provide in cast metal box with gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening. Provide caps with a spring-hinged flap. Receptacle shall be UL listed for use in "wet locations with plug in use."

2.14.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Device shall be capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A GFCI devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.14.4 Special Purpose Receptacles

Provide in ratings indicated. Furnish one matching plug with each receptacle.

2.14.5 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Plugs shall be UL listed with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.14.6 Range Receptacles

NEMA 14-50 configuration, flush mounted for housing units, rated 50 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.14.7 Dryer Receptacles

NEMA 14-30 configuration, rated 30 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.14.8 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.15 PANELBOARDS

UL 67 and UL 50 having a short-circuit current rating as indicated. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped unless indicated otherwise. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise. Main breaker shall be "separately" mounted "above" or "below" branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from Panel MDP). Provide new directories for existing panels modified by this project as indicated. Type directories and mount in holder behind transparent protective covering. Panelboards shall be listed and labeled for their intended use. Panelboard shall have nameplates in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.15.1 Enclosure

Enclosures shall meet the requirements of UL 50. All cabinets shall be fabricated from sheet steel of not less than 3.5 mm (No. 10 gauge) if flush-mounted or mounted outdoors, and not less than 2.7 mm (No. 12 gauge) if surface-mounted indoors, with full seam-welded box ends. Cabinets mounted outdoors or flush-mounted shall be hot-dipped galvanized after fabrication. Cabinets shall be painted in accordance with paragraph PAINTING. Outdoor cabinets shall be of NEMA 3R raintight with a removable steel plate 7 mm 1/4 inch thick in the bottom for field drilling for conduit connections. Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be so fabricated that no part of any surface on the finished cabinet shall deviate from a true plane by more than 3 mm (1/8 inch). Holes shall be provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 15 mm (1/2 inch) clear space between the back of the cabinet and the wall surface. Flush doors shall be mounted on hinges that expose only the hinge roll to view when the door is closed. Each door shall be fitted with a combined catch and lock, except that doors over 600 mm (24 inches) long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided with each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets.

2.15.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet. In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated.

2.15.2.1 Panelboard Neutrals for Non-Linear Loads

UL listed, and panelboard type shall have been specifically UL heat rise tested for use on non-linear loads. Panelboard shall be heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing. Verification of the testing procedure shall be provided upon request. Two neutral assemblies paralleled together with cable is not acceptable. Nameplates for panelboard rated for use on non-linear loads shall be marked "SUITABLE FOR NON-LINEAR LOADS" and shall be in accordance with paragraph FIELD FABRICATED NAMEPLATES. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.15.3 Circuit Breakers

UL 489, thermal magnetic-type or solid state-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker shall be mounted. Breaker terminals shall be UL listed as suitable for type of conductor provided. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.15.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.15.3.2 Circuit Breaker With GFCI

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A GFCI devices, for personnel protection, and 20 milliamperes or greater per requirements of UL 943 for Class B GFCI per equipment protection.

2.15.3.3 Circuit Breakers for HVAC Equipment

Circuit breakers for HVAC equipment having motors (group or individual) shall be marked for use with HACR type and UL listed as HACR type.

2.15.3.4 Arc-Fault Circuit-Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breaker shall be rated as indicated. Two pole arc-fault circuit-interrupters shall be rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable. Provide with "push-to-test" button.

2.15.4 Fusible Switches for Panelboards

NEMA KS 1, hinged door-type. Switches serving as motor disconnect means shall be kilowatt (horsepower) rated.

2.15.5 400 Hz Panelboard and Breakers

Panelboards and breakers for use on 400 Hz systems shall be "400 Hz" rated and labeled.

2.16 RESIDENTIAL LOAD CENTERS

Provide residential load centers (RLCs), conforming to UL 67 and UL 50. RLCs for use as service disconnecting means shall additionally conform to UL 869A. RLCs shall be circuit breaker equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. Where "space only" is indicated, make provisions for future installation of breakers sized as indicated. Load centers shall have keyed locks. Printed directories shall be provided.

2.16.1 RLC Buses

Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide isolated groundable neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.16.2 Circuit Breakers

UL 489, thermal magnetic-type with interrupting capacity as indicated. Breaker terminals shall be UL listed as suitable for the type of conductor provided.

2.16.2.1 Multipole Breakers

Provide common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any two adjacent breaker poles are connected to alternate phases in sequence.

2.16.2.2 Circuit Breaker With GFCI

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A GFCI devices.

2.16.2.3 Arc-Fault Circuit-Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breaker shall be rated as indicated. Two pole arc-fault circuit-interrupters shall be rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable. Provide with "push-to-test" button.

2.17 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated. Provide solid neutral.

2.18 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors, also called motor circuit protectors (MCPs); shall conform to UL 508 and UL 489 and shall be provided as shown. MSCPs shall consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. MSCPs shall be rated in accordance with the requirements of NFPA 70.

2.19 TRANSFORMERS

NEMA ST 20, general purpose, dry-type, self-cooled, ventilated. Provide transformers in NEMA 1 or 3R enclosure, as indicated. Transformer shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C. Transformer of 115 degrees C temperature rise shall be capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.19.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, shall be energy efficient type. Minimum efficiency, based on factory test results, shall not be less than NEMA Class 1 efficiency as defined by NEMA TP 1.

2.19.2 Transformers With Non-Linear Loads

Transformer insulation shall be a UL recognized 220 degrees C system. Neither the primary nor the secondary temperature shall exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load. Transformers are to be UL listed and labeled for K-Factor rating as indicated in accordance with UL 1561. Transformers evaluated by the UL K-Factor evaluation shall be listed for 115 degrees C average temperature rise only. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise shall not be acceptable. K-Factor rated transformers shall have an impedance range of 3 percent to 5 percent, and shall have a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

2.20 MOTORS

NEMA MG 1 except fire pump motors shall be as specified in Section 21 30 00 FIRE PUMPS; hermetic-type sealed motor compressors shall also comply with UL 984. Provide the size in terms of kW (HP), or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters. Motors for operation on 208-volt, 3-phase circuits shall have terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits shall have terminal voltage rating of 460 volts. Motors shall be designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating. Unless otherwise indicated, motors rated 745 Watts (1 HP) and above shall be continuous duty type.

Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

2.20.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.20.2 Premium Efficiency Polyphase Motors

Polyphase motors shall be selected based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10. In addition, continuous rated, polyphase squirrel-cage medium induction motors shall meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.20.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and over-voltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.20.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment as specified herein. Power wiring and conduit shall conform to the requirements specified herein. Control wiring shall be provided under, and conform to the requirements of the section specifying the associated equipment.

2.21 MOTOR CONTROLLERS

UL 508, NEMA ICS 1, and NEMA ICS 2, except fire pump controllers shall be as specified in Section 21 30 00 FIRE PUMPS. Controllers shall have thermal overload protection in each phase and shall have one spare normally open and one spare normally closed auxiliary contact. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and over-voltage. Provide protection for motors from immediate restart by a time adjustable restart relay. Magnetic-type motor controllers shall have undervoltage protection when used with momentary-contact pushbutton stations or switches and shall have undervoltage release when used with maintained-contact pushbutton stations or switches. When used with pressure, float, or similar automatic-type or maintained-contact switch, controller shall have hand/off/automatic selector switch. Connections to selector switch shall be such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices, shall be connected in motor control circuit in "hand" and "automatic" positions. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device shall be made in accordance with indicated or manufacturer's approved wiring diagram. For each motor not in sight of controller or where controller disconnecting means is not in sight of motor location and driven machinery location, controller disconnecting means shall be capable of being locked in open position. As an alternative, provide a manually operated, lockable, nonfused switch which disconnects motor from supply source within sight of motor. Overload protective devices shall provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case. Cover of combination motor controller and manual switch or circuit breaker shall be interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position. Provide controllers in hazardous locations with classifications as indicated.

2.21.1 Control Wiring

All control wire shall be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.21.2 Control Circuit Terminal Blocks

NEMA ICS 4. Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement shall be subject to the approval of the Contracting Officer and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. The

Contractor shall submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.21.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks shall meet the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.21.3 Control Circuits

Control circuits shall have maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers shall conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits, shall have primary windings wound for voltage available and secondary windings wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. One secondary lead shall be fused; other shall be grounded. For designated systems, as indicated, provide backup power supply, including transformers connected to emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit.

2.21.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.21.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers shall have compelling relays and shall be multiple-button, station-type with pilot lights for each speed.

2.21.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations shall be heavy duty, oil-tight design.

2.21.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.21.8 Reduced-Voltage Controllers

Provide for polyphase motors .75 kilowatt (1 horsepower) and larger. Reduced-voltage starters shall be single-step, closed transition autotransformer, reactor, primary resistor-type, solid state-type, or as indicated, and shall have adjustable time interval between application of reduced and full voltages to motors. Wye-delta reduced voltage starter or part winding increment starter having adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced-voltage starters for starting of motor-generator sets, centrifugally operated equipment, or reciprocating compressors provided with automatic unloaders.

2.22 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single pole designed for flush mounting with overload protection and pilot lights.

2.22.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color shall be green in accordance with NEMA ICS 2.

2.23 MOTOR CONTROL CENTERS

UL 845, NEMA ICS 2, NEMA ICS 3. Wiring shall be Class I or II, Type A, B, or C, in NEMA Type 1, 3R, or 12 enclosure, as indicated on drawings. Provide control centers suitable for operation with electrical ratings and minimum short-circuit withstand and interrupting rating of amperes rms symmetrical as indicated on drawings. Incoming power feeder shall be bus duct or cable entering at the top or bottom of enclosure and terminating on terminal lugs or main protective device as indicated. Main protective device shall be molded case circuit breaker, low-voltage power circuit breaker, or fusible switch rated at amperes rms symmetrical interrupting capacity as indicated. Arrange busing so that control center can be expanded from both ends. Interconnecting wires shall be copper. Terminal blocks shall be plug-in-type so that controllers may be removed without disconnecting individual control wiring.

2.23.1 Bus Systems

Provide the following bus systems. Power bus shall be braced to withstand fault current amperes rms symmetrical as indicated. Wiring troughs shall be isolated from horizontal and vertical bus bars.

2.23.1.1 Horizontal and Main Buses

Horizontal bus shall have continuous current rating as indicated. Main bus shall be copper, silver-plated enclosed in isolated compartment at top of each vertical section. Main bus shall be isolated from wire troughs, starters, and other areas.

2.23.1.2 Vertical Bus

Vertical bus shall have continuous current rating as indicated, and shall be copper, silver-plated. Vertical bus shall be enclosed in flame-retardant, polyester glass "sandwich."

2.23.1.3 Ground Bus

Copper ground bus shall be provided full width of motor control center and shall be equipped with necessary lugs.

2.23.1.4 Neutral Bus

Insulated neutral bus shall be provided continuous through the motor control center; neutral shall be fully rated. Lugs of appropriate capacity shall be provided, as required.

2.23.2 Motor Disconnecting Devices and Controllers

Shall comply with paragraph COMBINATION MOTOR CONTROLLERS.

2.23.3 Combination Motor Controllers

UL 508 and other requirements in paragraph, MOTOR CONTROLLERS. Controller shall employ molded case circuit breaker. Minimum short circuit withstand rating of combination motor controller shall be as indicated. Circuit breakers for combination controllers shall be thermal magnetic.

2.23.4 Space Heaters

Space heaters shall be provided where indicated on the drawings and shall be controlled using an adjustable 10 to 35 degrees C (50 to 90 degrees F) thermostat, magnetic contactor, and a molded-case circuit breaker and a 480-120 volt single-phase transformer. The space heaters shall be 250-watt, 240 volt strip elements operated at 120 volts and shall be supplied from the motor control center bus. The contactors shall be open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

2.24 LOCKOUT REQUIREMENTS

Provide disconnecting means capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 23, "Mechanical."

2.25 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires, wireways, or cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.26 COMMUNITY ANTENNA TELEVISION (CATV) SYSTEM

Additional CATV requirements are specified in Section 27 54 00.00 20, COMMUNITY ANTENNA TELEVISION (CATV) SYSTEMS.

2.26.1 CATV Outlets

Provide flush mounted, 75-ohm, F-type connector outlet rated from 5 to 1000 MHz in standard electrical outlet boxes with isolation barrier with mounting frame.

2.26.2 CATV Faceplates

Provide modular faceplates for mounting of CATV Outlets. Faceplate shall include designation labels and label covers for circuit identification. Faceplate color shall match outlet and switch cover plates.

2.26.3 Backboards

Coordinate CATV backboard requirements with telecommunications backboard requirements as specified in Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING.

2.27 GROUNDING AND BONDING EQUIPMENT

2.27.1 Ground Rods

UL 467. Ground rods shall be sectional type, copper-clad steel, with minimum diameter of 19 mm (3/4 inch) and minimum length of 3050 mm (10 feet).

2.27.2 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated.

2.27.3 Telecommunications and CATV Grounding Bus bar

Provide corrosion-resistant grounding bus bar suitable for indoor installation in accordance with TIA-607. Bus bars shall be plated for reduced contact resistance. If not plated, the bus bar shall be cleaned prior to fastening the conductors to the bus bar, and an anti-oxidant shall be applied to the contact area to control corrosion and reduce contact resistance. Provide a telecommunications main grounding bus bar (TMGB) in the telecommunications entrance facility and a (TGB) in all other telecommunications rooms and equipment rooms. The telecommunications main grounding bus bar (TMGB) and the telecommunications grounding bus bar (TGB) shall be sized in accordance with the immediate application requirements and with consideration of future growth. Provide telecommunications grounding bus bars with the following:

a. Predrilled copper bus bar provided with holes for use with standard sized lugs,

b. Minimum dimensions of 6 mm (0.25 in) thick by 100 mm (4 in) wide for the TMGB and 50 mm (2 in) wide for TGBs with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.28 HAZARDOUS LOCATIONS

Electrical materials, equipment, and devices for installation in hazardous locations, as defined by NFPA 70, shall be specifically approved by

Underwriters' Laboratories, Inc., or Factory Mutual for particular "Class," "Division," and "Group" of hazardous locations involved. Boundaries and classifications of hazardous locations shall be as indicated. Equipment in hazardous locations: comply with UL 1203 for electrical equipment and industrial controls and UL 674 for motors.

2.29 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.30 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (1.0 by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

2.31 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. The marking shall be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.32 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00, FIRESTOPPING .

2.33 WIREWAYS

UL 870. Material shall be steel galvanized 16 gauge for heights and depths up to 150 by 150 mm (6 by 6 inches), and 14 gauge for heights and depths up to 305 by 305 mm (12 by 12 inches). Provide in length indicated with screw-cover NEMA 1, 3R, or 12 enclosure as indicated per NEMA ICS 6.

2.34 METERING

ANSI C12.1. Provide a self-contained, socket-mounted, electronic programmable outdoor watthour meter. Meter shall either be programmed at the factory or shall be programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements.

KWH meters installed in facilities at USAG-Humphreys shall be compatible with existing Utilities Monitoring and Control System (UMCS). Current transformers and transducer equipment compatible with LON Works shall be provided and installed.

a. Design: Provide watthour meter designed for use on a single-phase, three-wire, 240/120 volt system. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Class: 200; Form: 2S, accuracy: plus or minus 1.0 percent; Finish: Class II.

c. Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

d. Kilowatt-hour Register: five digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on the meter face.

(3) Demand interval length: Shall be programmed for 15 minutes with rolling demand up to six subintervals per interval.

f. Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having manual circuit-closing bypass and having jaws compatible with requirements of the meter. Provide manufacturers standard enclosure color unless otherwise indicated.

2.35 METER BASE ONLY

ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having jaws compatible with requirements of a class: 200 and Form: 2S self contained watthour meter. Provide gray plastic closing cover and bypass links. Provide manufacturers standard enclosure color unless otherwise indicated.

2.36 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices which comply with UL 1449 where indicated. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Each phase to neutral (L-N)
Neutral to ground (N-G)
Phase to ground (L-G)

Surge protective devices at the service entrance shall have a minimum surge current rating of 80,000 amperes per mode minimum and downstream protectors shall be rated 40,000 amperes per mode minimum. The maximum line to neutral (L-N) Suppressed Voltage Rating (SVR) shall be:

500V for 120V, single phase system
500V for 120/240V, single phase system
500V for 208Y/120V, three phase system
900V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating shall be:

150V for 120V, single phase system
300/150V for 120/240V, single phase system
300/150V for 208Y/120V, three phase system
600/320V for 480Y/277V, three phase system

EMI/RFI filtering shall be provided for each mode with the capability to attenuate high frequency noise. Minimum attenuation shall be 20db.

2.37 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements as specified herein. Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray, and equipment located outdoors shall be ANSI Dark Gray. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.38 SOURCE QUALITY CONTROL

2.38.1 Transformer Factory Tests

Submittal shall include routine NEMA ST 20 transformer test results on each transformer and also contain the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.39 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces, shall conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit shall be continuous from service entrance equipment to outdoor power system connection.

3.1.2 Overhead Service

Overhead service conductors into buildings shall terminate at service entrance fittings or weatherhead outside building. Overhead service conductors and support bracket for overhead conductors are included in

Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.1.3 Hazardous Locations

Work in hazardous locations, as defined by NFPA 70, shall be performed in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Conduit shall have tapered threads.

3.1.4 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures shall be labeled and identified as such.

3.1.4.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, each enclosure, new and existing, shall be labeled as one of several enclosures containing service entrance disconnect devices. Label, at minimum, shall indicate number of service disconnect devices housed by enclosure and shall indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 6.35 mm (0.25 inch) in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure, shall be provided only as permitted by NFPA 70.

3.1.5 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor shall be separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size shall be 16 mm (1/2 inch) in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings shall be made with metal conduit in fire-rated shafts. Metal conduit shall extend through shafts for minimum distance of 150 mm (6 inches). Conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors shall be firestopped in accordance with Section 07 84 00, FIRESTOPPING.

3.1.5.1 Pull Wire

Install pull wires in empty conduits. Pull wire shall be plastic having minimum 890-N (200-pound) force tensile strength. Leave minimum 915 mm 36 inches of slack at each end of pull wire.

3.1.5.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.1.5.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

3.1.5.4 Flat Conductor Cable

Install in accordance with NFPA 70, Type FCC cable.

3.1.6 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 150 mm (6 inches) away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.6.1 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).3.1.6.2 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40 and PVC Schedule 80

(1) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in fire pump rooms.

(4) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

(5) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

(6) Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.3 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.6.4 Service Entrance Conduit, Overhead

Rigid steel or IMC from service entrance to service entrance fitting or weatherhead outside building.

3.1.6.5 Service Entrance Conduit, Underground

PVC, Type-EPC 40, galvanized rigid steel or steel IMC. Underground portion shall be encased in minimum of 75 mm (3 inches) of concrete and shall be installed minimum 460 mm (18 inches) below slab or grade.

3.1.6.6 Underground Conduit Other Than Service Entrance

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating shall extend minimum 150 mm (6 inches) above floor.

3.1.6.7 Conduit Interior to Buildings for 400 Hz Circuits

Aluminum or nonmetallic. Where 400-Hz circuit runs underground or through concrete, conduit shall be PVC Schedule 40.

3.1.6.8 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.6.9 Conduit Installed Under Floor Slabs

Conduit run under floor slab shall be located a minimum of 305 mm (12 inches) below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.6.10 Conduit Through Floor Slabs

Where conduits rise through floor slabs, curved portion of bends shall not be visible above finished slab.

3.1.6.11 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC; or PVC, Type EPC-40, unless indicated otherwise. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends shall not be visible above finish slab. Increase slab thickness as necessary to provide minimum 25 mm (one inch) cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings shall allow horizontal and vertical movement of raceway. Conduit larger than 27 mm (one inch) trade size shall be parallel with or at right angles to main reinforcement; when at right angles to reinforcement, conduit shall be close to one of supports of slab. Where nonmetallic conduit is used, raceway shall be converted to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

3.1.6.12 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 150 mm (6 inches) above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.6.13 Conduit Support

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceiling shall be vibration resistant and shock-resistant. Holes cut to depth of more than 40 mm (1 1/2 inches) in reinforced concrete beams or to depth of more than 20 mm (3/4 inch) in concrete joints shall not cut main reinforcing bars. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Installation shall be coordinated with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 3050 mm (10 foot) maximum intervals. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 63 mm (2 1/2 inches) inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6.14 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.6.15 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.6.16 Flexible Connections

Provide flexible steel conduit between 915 and 1830 mm (3 and 6 feet) in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size shall be 16 mm (1/2 inch) diameter. Provide liquidtight flexible nonmetallic conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.6.17 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room shall be installed and cabling length requirements in accordance with TIA-568-C.1. Size conduits, wireways, and cable tray in accordance with TIA-569 and as indicated.

b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling) shall be installed in accordance with TIA-569. Size conduits, wireways, and cable trays for telecommunications risers in accordance with TIA-569 and as indicated.

3.1.6.18 Community Antenna Television (CATV) System Conduits

Install a system of CATV wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires and other accessories for CATV outlets and pathway in accordance with TIA-569. Distribution system shall be star topology with empty conduit and pull wire from each outlet box to the telecommunications room.

3.1.7 Busway Installation

Installation shall comply at minimum with NFPA 70. Install busways parallel with or at right angles to ceilings, walls, and structural members. Support busways at 1525 mm (5 foot) maximum intervals, and brace to prevent lateral movement. Hinges provided on risers shall be fixed type; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam and caulk. Provide expansion joints, but only where bus duct crosses building expansion joints. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.8 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support in accordance with manufacturer recommendations but at not more than 1830 mm (6 foot) intervals. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section. Terminate cable trays 255 mm (10 inches) from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 103 mm (4 inch) rigid steel conduits with grounding bushings, extending 305 mm (12 inches) beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Penetrations shall be firestopped in accordance with Section 07 84 00, FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.9 Telecommunications Cable Support Installation

Install open top and closed ring cable supports on 1.2 m (4 ft) to 1.5 m (5 ft) centers to adequately support and distribute the cable’s weight. These types of supports shall be used to support a maximum of 50 6.4 mm (0.25 in) diameter cables. Install suspended cables with at least 75 mm (3 in) of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports shall be suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

3.1.10 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 2135 mm (7 feet) above floors and walkways, or when installed in hazardous areas and when specifically indicated. Boxes in other locations shall be sheet steel and nonmetallic boxes may be used with nonmetallic conduit system. Each box shall have volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures shall be minimum 100 mm (4 inches) square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; fixtures shall be readily removable for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. Threaded studs driven in by powder charge and provided with lock washers and nuts or nail-type nylon anchors may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 610 mm (24 inches) from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.10.1 Boxes

Boxes for use with raceway systems shall be minimum 40 mm (1 1/2 inches) deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 100 mm (4 inches) square, except that 100 by 50 mm (4 by 2 inch) boxes may be used where only one raceway enters outlet. Telecommunications outlets shall be a minimum of 120 mm square by 54 mm deep (4 11/16 inches square by 2 1/4 inches deep). Mount outlet boxes flush in finished walls.

3.1.10.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, and compatible with nonmetallic raceway systems, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.10.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.11 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 1980 mm (78 inches) above floor. Mount lighting switches and handicapped telecommunications stations 1220 mm (48 inches) above finished floor. Mount receptacles and telecommunications outlets 460 mm (18 inches) above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets shall be mounted at height 1525 mm (60 inches) above finished floor. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet. Measure mounting heights of receptacle outlet boxes in the hazardous area to the bottom of the outlet box.

3.1.12 Nonmetallic Sheathed Cable Installation

Where possible, install cables concealed behind ceiling or wall finish. Thread cables through holes bored on approximate centerline of wood members; notching of end surfaces is not permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel to or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 1220 mm (4 feet) above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in studs at each point through which cable passes, prior to installation of cable.

3.1.13 Mineral Insulated, Metal Sheathed (Type MI) Cable Installation

Mineral-insulated, metal-sheathed cable system, Type MI, may be used in lieu of exposed conduit and wiring. Conductor sizes shall be not less than those indicated for the conduit installation. Cables shall be fastened within 305 mm (12 inches) of each turn or offset and at 830 mm

(33 inches) maximum intervals. Make cable terminations in accordance with NFPA 70 and cable manufacturer's recommendations. Single-conductor cables of a circuit, having capacities of more than 50 amperes, shall terminate in a single box or cabinet opening. Individual conductors in all outlets and cabinets shall be color-coded.

3.1.14 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, color coding shall be by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, color coding shall be by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.14.1 Marking Strips

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. The wire numbers shall be made with permanent ink. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits shall be provided for the Government's wire designations. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.15 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.16 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 0.58 mm (1/16 inch). Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.17 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.18 Grounding and Bonding

Provide In accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, grounding conductor of nonmetallic sheathed cables, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. Make ground connection to driven ground rods on exterior of building. Interconnect all grounding media in or on the structure to provide a common ground potential. This shall include lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Interconnection to the gas line shall be made on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.18.1 Ground Rods

Provide cone pointed ground rods. The resistance to ground shall be measured using the fall-of-potential method described in IEEE 81. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, additional rod not less than 1830 mm (6 feet) on centers, and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.18.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.18.3 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm (4 inches) above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, ground buses shall be provided and connected to the building grounding system. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.18.4 Resistance

Maximum resistance-to-ground of grounding system shall not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.18.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding bus bars: Provide a telecommunications main grounding bus bar (TMGB) in the telecommunications entrance facility. The TMGB shall be as close to the electrical service entrance grounding connection as practicable. Telecommunications grounding bus bars shall be installed to maintain clearances as required by NFPA 70 and shall be insulated from its support. A minimum of 50 mm (2 inches) separation from the wall is recommended to allow access to the rear of the bus bar and the mounting height shall be adjusted to accommodate overhead or under floor cable routing.

b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the TMGB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 1 m (3 feet) in length, the conductors shall be bonded to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the TMGB shall utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. All metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the TMGB shall be bonded to the TMGB. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; TMGB shall be bonded to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, the metal frame shall be bonded to the TGB or TMGB with a minimum No. 6

AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the TGB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building shall be listed for the intended purpose.

3.1.19 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications but shall be provided under the section specifying the associated equipment.

3.1.20 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at vertical midpoint height of elevator shaft, and work light and outlet receptacle in elevator pit.

3.1.21 Government-Furnished Equipment

Contractor shall make connections to Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.22 Repair of Existing Work

Repair of existing work, demolition, and modification of existing electrical distribution systems shall be performed as follows:

3.1.22.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.22.2 Existing Concealed Wiring to be Removed

Existing concealed wiring to be removed shall be disconnected from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.22.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment shall include equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's power source as indicated.

3.1.22.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Existing circuits of equipment shall remain energized. Circuits which are to remain but were disturbed during demolition shall have circuits wiring and power restored back to original condition.

3.1.23 Watthour Meters

ANSI C12.1.

3.1.24 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each tests.

3.5.1 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 250,000 ohms.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

3.5.5 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.6 Watthour Meter

a. Visual and mechanical inspection

(1) Examine for broken parts, shipping damage, and tightness of connections.

(2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

(1) Determine accuracy of meter.

(2) Calibrate watthour meters to one-half percent.

(3) Verify that correct multiplier has been placed on face of meter, where applicable.

(4) Perform field verification test after installing watthour meter. Place external energy logger on same circuit upon which Watthour Meter is installed for at least 48 hours and compare kWh log with installed watthour meter. Contractor shall provide results of field verification test to Contracting Officer Representative or Base Civil Engineer (for Air Force projects) upon request. (

-- End of Section --

SECTION 26 23 00

SWITCHBOARDS AND SWITCHGEAR
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.15	(1990) Solid-State Demand Registers for Electromechanical Watthour Meters
ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D149	(2009; R 2013) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D1535	(2013) Specifying Color by the Munsell System
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C12.16	(1991) Solid-State Electricity Meters
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C37.13	(2008; INT 1 2009; AMD 1 2012) Standard

	for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1	(2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.90.1	(2012) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA ST 20	(1992; R 1997) Standard for Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1558	(1999; Reprint Apr 2010) Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

UL 198M	(2003; Reprint Feb 2013) Standard for Mine-Duty Fuses
UL 4248	(2007) UL Standard for Safety Fuseholders
UL 467	(2007) Grounding and Bonding Equipment
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard / Switchgear Drawings; G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Switchboard / Switchgear; G

SD-06 Test Reports

Switchboard / Switchgear design tests

Switchboard / Switchgear production tests

Acceptance checks and tests; G

SD-10 Operation and Maintenance Data

Switchboard / Switchgear Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals

Equipment Test Schedule; G

Request for Settings; G

1.5 QUALITY ASSURANCE

1.5.1 Switchboard / Switchgear Product Data

Each submittal shall include manufacturer's information for each component, device and accessory provided with the switchboard / switchgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings

b. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard / Switchgear Drawings

Drawings shall include, but are not limited to the following:

a. One-line diagram including breakers, fuses, current transformers, and meters

b. Outline drawings including front elevation, section views, footprint, and overall dimensions

c. Bus configuration including dimensions and ampere ratings of bus bars

d. Markings and NEMA nameplate data, including fuse information (manufacturer's name, catalog number, and ratings)

e. Circuit breaker type, interrupting rating, and trip devices, including available settings

f. Three-line diagrams and elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device. These shall be used by the designer of record to provide breaker settings that will ensure protection and coordination are achieved.

h. Provisions for future extension.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Switchboard / Switchgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Submit one hard copy and one digital copy (.pdf - text searchable) of Operation and Maintenance Manuals. Manuals shall be assembled and bound securely in durable, hard covered, water resistant binders. Digital copies shall be organized and indexed in same manner as hard copy. The manuals shall be assembled and indexed in the following order with a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information required by the paragraph entitled "SD-10, Operation and Maintenance Data".

b. Catalog data required by the paragraph entitled, "SD-03, Product Data".

c. Drawings required by the paragraph entitled, "SD-02, Shop Drawings".

d. Prices for spare parts and supply list.

f. Design test reports

g. Production test reports

1.6.3 Spare Parts

Spare parts shall be furnished as specified below. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished.

a. 2 - Fuses of each type and size.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchboards or switchgear and related accessories are specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 Switchboard / Switchgear

NEMA PB 2 and UL 891 or IEEE C37.20.1 and UL 1558, as applicable.

2.2.1 Ratings

The voltage rating of the switchboard / switchgear shall be as indicated, 2, 3, or 4-wire, single or 3 phase, as indicated. The continuous current rating of the main bus shall be as indicated. The short-circuit current rating shall be as indicated. The switchboard / switchgear shall be UL listed and labeled for its intended use.

2.2.2 Construction

Switchboard / switchgear shall consist of vertical sections bolted together to form a rigid assembly and shall be aligned as indicated. All circuit breakers shall be front accessible. Rear aligned switchboards shall have front accessible load connections. Front and rear aligned switchboards shall have rear accessible load connections. Compartmentalized switchboards / switchgear shall have vertical insulating barriers between the front device section, the main bus section, and the cable compartment with full front to rear vertical insulating barriers between adjacent sections. Where indicated, "space for future" or "space" shall mean to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1, Type GPO-3, 6.35 mm

(0.25 inch) minimum thickness. Apply moisture resistant coating to all rough-cut edges of barriers. Switchboard shall be completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

The switchboard / switchgear enclosure shall be a NEMA ICS 6 Type 3R or 1, as indicated, and fabricated entirely of 12 gauge ASTM A167 type 304 or 304L stainless steel. Enclosure shall be bolted together with removable bolt-on side and hinged rear covers, and sloping roof downward toward rear. Front and rear doors shall be provided with stainless steel padlockable vault handles with a three point catch. Bases, frames and channels of enclosure shall be corrosion resistant and shall be fabricated of ASTM A167 type 304 or 304L stainless steel. Base shall include any part of enclosure that is within 75 mm (3 inches) of concrete pad. Paint enclosure, including bases, ASTM D1535 light gray No. 61 or No. 49. Paint coating system shall comply with IEEE C57.12.29 for stainless steel.

2.2.2.2 Bus Bars

Bus bars shall be copper with silver-plated contact surfaces. Plating shall be a minimum of 0.005 mm (0.0002 inch) thick. Make bus connections and joints with hardened steel bolts. The through-bus shall be rated at the full ampacity of the main throughout the switchboard. Provide minimum 6.35 mm by 50.8 mm (one-quarter by 2 inch) copper ground bus secured to each vertical section along the entire length of the switchboard / switchgear. The neutral bus shall be rated 100 percent of the main bus continuous current rating. Phase bus bars shall be insulated with an epoxy finish coating powder providing a minimum breakdown voltage of 16,000 volts per ASTM D149.

2.2.2.3 Main Section

The main section shall consist of an individually mounted drawout, air power circuit breaker with current-limiting fuses, insulated-case circuit breaker, or molded-case circuit breaker, as indicated on drawings and utility transformer compartment.

2.2.2.4 Distribution Sections

The distribution sections shall consist of individually mounted,drawout, air power circuit breakers with current-limiting fuses, insulated-case circuit breakers, or molded-case circuit breakers, as indicated on drawings and utility transformer compartments as indicated.

2.2.2.5 Combination Sections

Combination sections shall consist of molded-case circuit breakers for the main and branch devices as indicated.

2.2.2.6 Auxiliary Sections

Auxiliary sections shall consist of indicated instruments, metering equipment, control equipment, transformer, and current transformer compartments as indicated.

2.2.2.7 Handles

Handles for individually mounted devices shall be of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Power Circuit Breaker

IEEE C37.13. Electrically operated drawout, fused, steel frame, low-voltage power circuit breaker with a short-circuit current rating as indicated at voltage indicated. Breaker frame size shall be as indicated. Equip electrically operated breakers with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.

2.2.3.2 Insulated-Case Breaker

UL listed, 100 percent rated, drawout, voltage as indicated, electrically operated, low voltage, insulated-case circuit breaker, with a short-circuit current rating and voltage as indicated. Breaker frame size shall be as indicated. Equip electrically operated breaker with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.

2.2.3.3 Molded-Case Circuit Breaker

UL 489. UL listed and labeled, 100 percent rated, drawout,voltage as indicated, electrically operated, low voltage molded-case circuit breaker, with a short-circuit current rating and voltage as indicated. Breaker frame size shall be as indicated. Series rated circuit breakers are unacceptable.

2.2.3.4 Fusible Switches

Fusible Switches: Quick-make, quick-break, hinged-door type. Switches serving as motor disconnects shall be horsepower rated. Fuses shall be current-limiting cartridge type conforming to UL 198M, Class J for 0 to 600 amperes and Class L for 601 to 6000 amperes or UL 198M, Class RK1 or RK5 for 0 to 600 amperes.

Fuseholders: UL 4248.

2.2.3.5 Integral Combination Breaker and Current-Limiting Fuses

UL 489. Provide integral combination molded-case circuit breaker and current-limiting fuses as indicated with a minimum short-circuit-current rating equal to the short-circuit-current rating of the switchboard / switchgear in which the circuit breaker will be mounted. Series rated circuit breakers are unacceptable. Coordination of overcurrent devices of the circuit breaker and current-limiting fuses shall be such that on overloads or fault currents of relatively low value, the overcurrent device of the breaker will be operated to clear the fault. For high magnitude short circuits above a predetermined value, the current-limiting fuses shall operate to clear the fault. Housing for the current-limiting fuses shall be an individual molding readily removable from the front and located at the load side of the circuit breaker. If the fuse housing is removed, a blown fuse shall be readily evident by means of a visible indicator. Removal of fuse housing shall cause the breaker contacts to open, and it shall not be possible to close the breaker contacts with the fuse housing removed. It shall not be possible to insert the fuse housing with a blown fuse or with one fuse missing. The blowing of any of the fuses shall cause the circuit breaker contacts to open.

2.2.4 Drawout Breakers

Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. The main, auxiliary, and control disconnecting contacts shall be silver-plated, multifinger, positive pressure, self-aligning type. Each drawout breaker shall be provided with four-position operation. Each position shall be clearly identified by an indicator on the circuit breaker front panel.

a. Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

b. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. Position shall allow complete test and operation of the breaker without energizing the primary circuit.

c. Disconnected Position: Primary and secondary contacts are disconnected.

d. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker shall actuate assembly that isolates the primary stabs.

2.2.5 Electronic Trip Units

Equip main and distribution breakers as indicated with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that will provide true rms sensing adjustable time-current circuit protection. The ampere rating of the current sensors shall be the same as the breaker frame rating. The trip unit ampere rating shall be as indicated. Ground fault protection shall be zero sequence sensing or residual type sensing, as indicated.

a. Breakers shall have long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.

b. Main breakers shall have short delay pick-up and time settings, instantaneous settings, and ground fault settings as indicated.

c. Distribution breakers shall have short delay pick-up and time settings, instantaneous settings, and ground fault settings as indicated.

d. Breakers shall have a digital display for phase and ground current.

e. Breakers shall have a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

f. Breakers shall have a digital display for phase voltage, and percent THD voltage and current.

g. Breakers shall have provisions for communication via a network twisted pair cable for remote monitoring and control.

2.2.6 Electronic Trip Unit Central Monitor

Provide a microprocessor-based device designed to monitor and display parameters of the circuit breaker electronic trip units. The central monitor shall have the following features:

a. Alphanumeric display.

b. Indication of circuit breaker status; tripped, open, closed.

c. Cause of circuit breaker trip.

d. Phase, neutral, and ground current for each breaker.

e. Energy parameters for each breaker.

f. Provisions for communicating directly to a remote computer.

2.2.7 Instruments

ANSI C39.1 for electrical indicating switchboard instruments, with 2 percent accuracy. The ac ammeters and voltmeters shall be a minimum of 50.8 mm square (2 inches square), with 4.36 rad (250-degree) scale. Provide single phase indicating instruments with flush-mounted transfer switches for reading three phases.

2.2.7.1 Ac Ammeters

Transformer rated, 5-ampere input, for use with a current transformer ratio and ampere scale range as indicated, 60 hertz.

2.2.7.2 Ac Voltmeters

Self-contained.

2.2.7.3 Instrument Control Switches

Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.

2.2.8 Watthour and Digital Meters

2.2.8.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in sealed cases with a simultaneous three line, twelve value LED display. Meters shall have 16 mm (0.56 inch), minimum, LEDs. Watthour meter shall have 16 mm (0.56 inch), minimum, LEDs. The meters shall accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to 600 volts, phase to phase. Programming shall be via a front panel display and a communication interface with a computer. Password secured programming shall be stored in non-volatile EEPROM memory. Digital communications shall be Modbus RTU protocol via a RS232C or RS485 serial port and an independently addressable RS232C or RS485 serial port. The meter shall calculate and store average max/min demand values for all readings based on a user selectable sliding window averaging period. The meter shall have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

a. Multi-Function Meter: Meter shall simultaneously display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. The meter shall have a Form C KYZ pulse output relay.

b. Power Meter: Meter shall simultaneously display Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power.

c. Volt Meter: Meter shall be selectable between simultaneous display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, over percent THD.

d. Ammeter: Meter shall simultaneously display phase A, B, and C currents. Detected alarm conditions include over/under current, over percent THD.

e. Digital Watthour Meter: Meter shall have a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). The meter shall have a Form C KYZ pulse output relay.

2.2.8.2 Electronic Watthour Meter

Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. Meter shall be coordinated to system requirements and conform to IEEE C12.16.

a. Design: Provide meter designed for use on a 3-phase, 4-wire, 208Y/120 or 480Y/277 volt system with 3 current transformers, as indicated. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class: 20. Form: 9S. Accuracy: plus or minus 1.0 percent. Finish: Class II.

d. Kilowatt-hour Register: 5 digit electronic programmable type.

e. Demand Register:

1. Provide solid state ANSI C12.15.

2. Meter reading multiplier: Indicate multiplier on the meter face.

3. Demand interval length: shall be programmed for 15 minutes with rolling demand up to six subintervals per interval.

f. Meter fusing: Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

2.2.9 Current Transformers

IEEE C57.13. Transformers shall be single ratio, 60 hertz, ratio as indicated on drawings, rating factor as indicated in the table below, with a metering accuracy class of as indicated in the table below.

RATIO	RF at 30 degrees C
200/5	4.0
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5
1500/5	1.5
2000/5	1.5
3000/5	1.33

Primary Amp Rating (of CT)	Accuracy Class
200	0.3 thru B-0.1
300-400	0.3 thru B-0.2
600-1200	0.3 thru B-0.5
1500	0.3 thru B-0.9
2000-3000	0.3 thru B-1.8

2.2.10 Transformer

Provide transformer section in switchboard / switchgear in accordance with UL 891 or UL 1558 and as indicated. The transformer and section shall be suitable for the installation. Transformers greater than 10 kVA shall be tested in accordance with UL 891. Transformer shall conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2.11 Heaters

Provide 120-volt heaters in each switchboard / switchgear section. Heaters shall be of sufficient capacity to control moisture condensation in the section, shall be 250 watts minimum, and shall be controlled by a thermostat and humidistat located in the section. Thermostat shall be industrial type, high limit, to maintain sections within the range of 15 to 32 degrees C (60 to 90 degrees F). Humidistat shall have a range of 30 to 60 percent relative humidity. Supply voltage for the heaters shall be obtained from a control power transformer within the switchboard / switchgear. If heater voltage is different than switchboard voltage, provide transformer rated to carry 125 percent of heater full load rating. Transformer shall have 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and shall conform to NEMA ST 20. Energize electric heaters in switchboard assemblies while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source. Provide temporary, reliable external power source if commercial power at rated voltage is not available on site.

2.2.12 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

2.2.13 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, switchgear, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

   1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

   2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

   3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

   4. Dated calibration labels shall be visible on all test equipment.

   5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

   6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

      (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

      (b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard / Switchgear Design Tests

NEMA PB 2 and UL 891 or IEEE C37.20.1 and UL 1558, as applicable.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test

b. Enclosure tests

c. Dielectric test

2.5.3 Switchboard / Switchgear Production Tests

NEMA PB 2 and UL 891 or IEEE C37.20.1 and UL 1558, as applicable. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests

b. Mechanical operation tests

c. Electrical operation and control wiring tests

d. Ground fault sensing equipment test

2.6 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 610 mm (24 inches) below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

ANSI/NEMA PB 2.1.

3.3.2 Switchgear

IEEE C37.20.1.

3.3.3 Meters and Instrument Transformers

ANSI C12.1.

3.3.4 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.5 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.6 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount switchboard / switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inch) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inch) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turn ups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount switchboard / switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turn ups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Contractor shall submit request for settings of breakers to the Contracting Officer after approval of switchboard / switchgear and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings.

7. Verify that current transformer ratios correspond to approved shop drawings.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method,

or performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Clean switchboard.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform overpotential tests.

3. Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

6. Perform phasing check on double-ended switchboard to ensure correct bus phasing from each source.

7. Verify operation of switchboard heaters.

3.5.1.2 Switchgear

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings.

7. Verify that current transformer ratios correspond to approved shop drawings.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Clean switchgear.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform overpotential tests.

3. Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

6. Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

7. Verify operation of switchgear heaters.

3.5.1.3 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and alignment.

5. Verify that all maintenance devices are available for servicing and operating the breaker.

6. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

7. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Verify cell fit and element alignment.

10. Verify racking mechanism.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust Breaker(s) for final settings in accordance with Government provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

11. Verify operation of charging mechanism.

3.5.1.4 Circuit Breakers

Low Voltage - Insulated-Case and Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect circuit breaker for correct mounting.

3. Operate circuit breaker to ensure smooth operation.

4. Inspect case for cracks or other defects.

5. Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

6. Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

1. Perform contact-resistance tests.

2. Perform insulation-resistance tests.

3. Perform Breaker adjustments for final settings in accordance with Government provided settings.

4. Perform long-time delay time-current characteristic tests

3.5.1.5 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.6 Metering and Instrumentation

a. Visual and Mechanical Inspection

   1. Compare equipment nameplate data with specifications and approved shop drawings.

   2. Inspect physical and mechanical condition.

   3. Verify tightness of electrical connections.

b. Electrical Tests

   1. Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

   2. Calibrate watthour meters according to manufacturer's published data.

   3. Verify all instrument multipliers.

   4. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.7 Grounding System

a. Visual and Mechanical Inspection

   1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

   1. IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

   2. Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions

at the time the measurements were made.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D2472	(2000; R 2006) Standard Specification for Sulphur Hexafluoride

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE 32	(1972; R 1997) Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices
IEEE 484	(2002; R 2008) Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications
IEEE C37.04	(1999; R 2006; AMD 1 2003; R 2006; ERTA 2005; R 2006; AMD 2 2008; CORR 2009; INT 2010) Standard for Rating Structure for AC High-Voltage Circuit Breakers
IEEE C37.06	(2009) Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities for Voltage Above 1000 V
IEEE C37.13	(2008; INT 1 2009; AMD 1 2012) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.16	(2009) Standard for Preferred Ratings,

	Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers
IEEE C37.2	(2008) Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations
IEEE C37.20.1	(2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.20.2	(1999; Corr 2000; R 2005) Standard for Metal-Clad Switchgear
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE C37.30	(1997; INT 1 2011) Standard Requirements for High-Voltage Switches
IEEE C37.40	(2003; Errata 2003; R 2009) Service Conditions & Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, & Accessories
IEEE C37.46	(2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C57.15	(2009) Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA SG 4	(2009; R 2013) AC High-Voltage Circuit Breakers
NEMA SG 6	(2000) Standard for Power Switching Equipment
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1203	(2013) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 1236	(2006; Reprint Jul 2011) Standard for Battery Chargers for Charging Engine-Starter Batteries
UL 198M	(2003; Reprint Feb 2013) Standard for Mine-Duty Fuses
UL 486E	(2009; Reprint May 2013) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	(1999; Reprint Oct 2013) Industrial Control Equipment
UL 845	(2005; Reprint Jul 2011) Motor Control Centers

1.2 SYSTEM DESCRIPTION

Refer to contract drawings and documents for power system covered by this specification.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis
Protective Device Coordination Study
Equipment
System Coordinator
Protective Relays
Installation

SD-06 Test Reports

Field Testing

SD-07 Certificates

Devices and Equipment

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.6 PROJECT/SITE CONDITIONS

Submit certificates attesting that all devices or equipment meet the requirements of the contract documents. Devices and equipment furnished under this section shall be suitable for the service conditions as discussed in the references listed in the table below and as indicated on contract drawings and documents. Seismic details shall conform to UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT AND 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT .

ITEM OF EQUIPMENT	STANDARD
Batteries	IEEE 484
Battery Chargers	UL 1236
Instrument Transformers	IEEE C57.13
Switchgear	IEEE C37.20.1 IEEE C37.20.2 IEEE C37.20.3
Neutral Ground Resistors	IEEE 32
Power Circuit Breakers (Above 1000 Volts)	IEEE C37.04
Molded-Case Circuit Breakers	IEEE C37.13
Relays, Electrical Power Apparatus	IEEE C37.90
Step-Voltage Regulators	IEEE C57.15
Surge Arrestors	IEEE C62.11
Switches	IEEE C37.30 IEEE C37.40
Transformers	IEEE C57.12.00
Switchboards	NEMA PB 2

1.7 EXTRA MATERIALS

One additional spare fuse or spare fuse element for each furnished fuse or fuse element shall be delivered to the Contracting officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening. Submit data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with UL 489.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.4.1 Motor Starters

Provide combination starters with circuit breakers and fusible switches and switches equipped with high-interrupting-capacity current-limiting fuses as indicated.

2.4.2 Reduced-Voltage Starters

Provide reduced-voltage starters for polyphase motors as indicated on drawings. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor, may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.4.3 Thermal-Overload Protection

Each motor of 93 W (1/8 hp) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4.4 Low-Voltage Motor Overload Relays

2.4.4.1 General

Thermal and magnetic current overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second. Slow units shall be used for motor starting times from 8 to 12 seconds. Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.

2.4.4.2 Construction

Manual reset type thermal relays shall be melting alloy or bimetallic construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.4.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C (14 degrees F), an ambient temperature-compensated overload relay shall be provided.

2.4.5 Automatic Control Devices

2.4.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt (horsepower) rating.

2.4.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.4.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.4.6 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class and Type as indicted on drawings. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.5 LOW-VOLTAGE FUSES

2.5.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as shown . Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. Class H Fuses shall conform to UL 198M. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds. Cartridge fuses shall be used for circuits rated in excess of 30 amperes, 125 volts, except where current-limiting fuses are indicated.

2.5.3 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class G, J, K, L, RK1, RK5, RK9, T, or CC as indicated on drawing shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject Class H fuses.

a. Class G, J, L, and CC fuses shall conform to UL 198M.

b. Class K fuses shall conform to UL 198M.

c. Class R fuses shall conform to UL 198M.

d. Class T fuses shall conform to UL 198M.

2.5.3.1 Continuous Current Ratings (600 amperes and smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class RK1 or J, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.5.3.2 Continuous Current Ratings (greater than 600 amperes)

Service entrance and feeder circuit fuses (greater than 600 amperes) shall be Class L, current-limiting, with 200,000 amperes interrupting capacity.

2.5.3.3 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.6 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.6.1 General

Medium-voltage and high-voltage fuses shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.6.2 Construction

Units shall be suitable for outdoor or indoor use as indicated. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Continuous-current ratings shall be as shown.

2.6.3.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall be of the loadbreak or nonloadbreak as indicated on drawings, enclosed type construction rated for voltage as indicated on drawings and of the heavy-duty type, unless otherwise stated. Open-link cutouts are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuses cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.6.3.2 Power Fuses

Current-limiting power fuses shall have ratings in accordance with IEEE C37.46 and Nominal voltage, Rated maximum voltage, Maximum symmetrical interrupting capacity, Rated continuous current, and BIL as indicated on drawings.

2.6.3.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to IEEE C37.46.

2.6.3.4 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.6.3.5 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to IEEE C37.46.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.7.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.7.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.8 MOLDED-CASE CIRCUIT BREAKERS

2.8.1 General

Molded-case circuit breakers shall conform to UL 489 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 1203.

2.8.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.8.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with UL 489. Ratings shall be coordinated with system X/R ratio.

2.8.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.8.5 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.8.6 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as indicated on drawings.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload, Short-circuit, and Ground-fault trip indicators shall be provided.

2.8.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.8.8 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.8.9 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.8.10 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to UL 489 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.9 LOW-VOLTAGE POWER CIRCUIT BREAKERS

2.9.1 Construction

Low-voltage power circuit breakers shall conform to IEEE C37.13 and IEEE C37.16 and shall be three-pole, single-throw, stored energy, manually or electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be as indicated. The circuit breaker enclosure shall be suitable for its intended location.

2.9.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with IEEE C37.16. Tripping features shall be as follows:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as indicated on drawings.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload, Short-circuit, and Ground-fault trip indicators shall be provided.

2.10 MEDIUM-VOLTAGE CIRCUIT BREAKERS/INTERRUPTERS

2.10.1 Metal-Enclosed Type

Circuit breakers shall be of the drawout type, in accordance with IEEE C37.20.1.

2.10.2 Metal-Clad Type

Circuit breakers shall comply with IEEE C37.04 and shall consist of items listed for such units in NEMA SG 6.

2.10.3 SF6 Interrupters

SF6 interrupters shall be of the puffer type where the movement of the contact plunger will initiate the puff of SF6 gas across the contact to extinguish the arc at zero gauge tank pressure (atmospheric pressure). The puff of SF6 must be sufficient to clear an arc for 25 kV or lower class equipment unless otherwise indicated and remain operational without damage or requiring maintenance or repair except for gas leaks. Breakers shall be provided with a loss-of-pressure alarm remote as shown on the drawings. Before the pressure in the container drops below the point where the breaker or switch cannot open safely without damage, the breaker shall activate the loss-of-pressure alarm, open automatically, and remain in the locked open position until repaired. If located inside a structure, breakers shall be located in a closed room with access only from outside, and provided with direct outdoor ventilation and a sensor unit which activates a vent fan and an alarm when a SF6 leak had occurred. The alarm will automatically be silenced when the oxygen in the room is above 19.5 percent. The SF6 shall meet the requirements of ASTM D2472, except that the maximum dew point shall be minus 60 degrees C (140 degrees F) (corresponding to 11 ppm water by volume), with only 11 ppm water by volume, and the minimum purity shall be 99.9 percent by weight. Circuit breakers shall have provisions for maintenance slow closing of contacts and have a readily accessible contact wear indicator. Tripping time shall not exceed five cycles.

2.10.4 Vacuum Interrupters

Vacuum interrupters shall be hermetically-sealed in a high vacuum to protect contact from moisture and contamination. Circuit breakers shall have provisions for slow closing of contacts and have a readily contact wear indicator. Tripping time shall not exceed five cycles.

2.10.5 Ratings

Main buses shall be three-phase three-wire or four-wire, as indicated on drawings, with a continuous current rating as indicated on drawings. The neutral bus shall be rated as indicated on drawings Switchgear ratings at 60 Hz shall be in accordance with IEEE C37.06 and Maximum voltage, Nominal voltage class, BIL, Maximum symmetrical interrupting capacity, 3-second short-time-current carrying capacity, and Rated continuous current as indicated on drawings.

2.11 OIL CIRCUIT BREAKERS FOR SUBSTATIONS

Oil circuit breakers shall comply with IEEE C37.04 and NEMA SG 4and shall be of the outdoor three-pole type, with single or multiple tanks and frame-mounted or floor-mounted on a common base in accordance with the manufacturer's standard design. Control voltage and ratings shall be as indicated on drawings.

2.11.1 Incoming Line Circuit Breakers for Substations

Incoming line circuit breakers shall be coordinated with the requirements of the serving utility, and of the protected transformer, and shall include the following control and monitoring system items that shall be mounted in the instrument and relay cabinet.

a. An ammeter and an ammeter switch.

b. A circuit breaker control switch for local and remote control operation.

c. Three overcurrent relays, devices 50/51.

d. One residually-connected ground-overcurrent relay, device 50/51N.

e. Three directional overcurrent relays, device 67.

f. One ground-directional-overcurrent relay, device 67N.

g. Three transformer differential relays, device 87T and an auxiliary lockout relay, device 86T located in the associated metal-clad switchgear.

h. Three phase secondary potential test blocks with associated test plug, quantity as shown.

i. Three phase secondary current test blocks with associated test plug for each three-phase set of current transformers, as indicated.

2.11.2 Line Tie Circuit Breakers for Substations

The line tie circuit breaker shall be rated as shown , and shall be electrically and mechanically interlocked with other high-voltage items of equipment as shown. The line tie circuit breaker shall be equipped with control and monitoring system items the same as described for the incoming line circuit breaker. The instrument and relay cabinet shall house the same equipment listed for the incoming line circuit breaker cabinet except as indicated. The cabinet shall also house three bus differential relays, device 87B, and an auxiliary lockout relay, device 86B.

2.12 SUBSTATION AND SWITCHGEAR PROTECTIVE RELAYS

Microprocessor-based protective relays shall be as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall suitable for operation with the instrument transformer ratios and connections provided.

2.12.1 Construction

Relays for installation in metal-clad switchgear shall be of the semi-flush, rectangular, back-connected, dustproof, switchboard type. Cases shall have a black finish and window-type removable covers capable of being sealed against tampering. Relays shall be of a type that can be withdrawn, through approved sliding contacts, from fronts of panels or doors without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of any relay leads. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.12.2 Ratings

Relays shall be the manufacturer's standard items of equipments with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.12.3 Overcurrent Relays

Overcurrent relays shall be as follows:

a. Phase overcurrent relays for main and tie circuit breakers shall be single-phases, nondirectional, microprocessor-based type, time delay, device 51, current taps as indicated with characteristic curves that are as indicated.

b. Ground overcurrent relays for main circuit breakers shall be nondirectional, microprocessor-based type, time delay, device 51G wired to a current transformer in the source transformer neutral-to-ground connection or 51N, residually connected, as indicated with current taps as indicted and with characteristic curves that are as indicated.

c. Ground overcurrent relays for tie circuit breakers shall be nondirectional, microprocessor-based type, time delay, device 51N, residually connected, with current taps as indicated and with characteristic curves that are as indicated.

d. Phase overcurrent relays for feeder circuit breakers shall be single-phase, nondirectional, microprocessor-based type, device 50/51, with instantaneous-current pick-up range as indicated, with time-delay-current taps as indicated and with characteristic curves that are as indicated.

e. Ground overcurrent relays for feeder circuit breakers shall be nondirectional, microprocessor-based type instantaneous, device 50N, residually connected, with current pick-up range as indicated.

2.12.4 Directional Overcurrent Relays

Directional overcurrent relays shall be as follows:

a. Directional phase overcurrent relays shall be single-phase, microprocessor-based type, with instantaneous units. Phase relays, device 67, shall have an instantaneous-current pick-up range as indicated, with time-delay-current taps as indicated and with characteristic curves that are as indicated.

b. Directional ground overcurrent relays, device 67N, shall have an instantaneous-current pick-up range as indicated, with time-delay-current taps as indicated and with characteristic curves that are as indicated.

2.12.5 Automatic Reclosing Relay

Relay, device 79, shall be of the three-phase, four-reclosure type, providing immediate initial reclosure, and three time-delay reclosures. Adjustable time delays shall be 10 to 60 seconds for reset and 0 to 45 seconds for reclosing. Units shall have instantaneous trip lockout after any preset trip when closing in on a fault. Auxiliary devices shall provide for lockout when an associated circuit breaker is tripped after reclosures and automatically reset when an associated circuit breaker is not tripped after any reclosure.

2.12.6 Transformer Differential and Lockout Relays

Differential relays, device 87T, shall be of the three-phase or the single-phase high-speed percentage differential type suitable for the protection of two-winding transformers, and shall be provided with a harmonic-restraint feature. Lockout relay, device 86T, shall be of the type which, when used in conjunction with the 87T relay, trips and locks out the indicated circuit breakers.

2.12.7 Bus Differential and Lockout Relays

Bus differential relay, device 87B, shall be of the three-phase or single-phase, high-speed impedance differential type suitable for protection of buses. Lockout relay, device 86B, shall be of a type which, when used in conjunction with the 87B relay, trips and locks out the indicated circuit breaker.

2.13 INSTRUMENT TRANSFORMERS

2.13.1 General

Instrument transformers shall comply with NEMA/ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.13.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be as indicated in the table below. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

RATIO	RF at 30 degrees C
200/5	4.0

RATIO	RF at 30 degrees C
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5
1500/5	1.5
2000/5	1.5
3000/5	1.33

2.13.2.1 For Oil Circuit Breakers

Single-ratio or multi-ratio bushing type current transformers shall be provided in circuit breaker bushing wells as indicated. Single-ratio units shall have a minimum metering accuracy class rating of 0.3B-0.5. Multi-ratio units shall have a minimum relaying accuracy voltage class as indicated on contract drawings and documents for either a C or T classification.

2.13.2.2 For Power Transformers

Single-ratio or multi-ratio bushing type current transformers shall be provided internally around power transformer bushings as shown. Single-ratio units shall have a minimum metering accuracy class of 0.3B-0.5. Multi-ratio units shall have a minimum relaying accuracy voltage class 0.3 for either a C or T classification.

2.13.2.3 For Metal-Clad Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating as indicated in the table below. Single-ratio units, used only for relaying, shall have a relaying accuracy class rating as indicated for either a C or T classification.

Primary Amp Rating (of CT)	Accuracy Class
200	0.3 thru B-0.1
300-400	0.3 thru B-0.2
600-1200	0.3 thru B-0.5
1500	0.3 thru B-0.9

Primary Amp Rating (of CT)	Accuracy Class
2000-3000	0.3 thru B-1.8

2.13.2.4 For kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy Class as indicated in the table below, with a minimum RF as indicated in the table below at 30 degrees C (86 degrees F), with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted on the transformer low-voltage bushings shall be provided. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters.

Primary Amp Rating (of CT)	Accuracy Class
200	0.3 thru B-0.1
300-400	0.3 thru B-0.2
600-1200	0.3 thru B-0.5
1500	0.3 thru B-0.9
2000-3000	0.3 thru B-1.8

RATIO	RF at 30 degrees C
200/5	4.0
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5
1500/5	1.5
2000/5	1.5
3000/5	1.33

2.13.2.5 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy rating of .3% at all burdens W, X, Y, and Z. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.14 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.14.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses; the source bus and extended through the secondary side of transformers for medium voltage distribution feeders; the source bus and extend through outgoing breakers and outgoing medium voltage feeders, down to the individual protective devices for medium voltage radial taps; outgoing medium voltage feeders, through the secondary side of transformers for main electric supply substations; the nearest upstream device in the existing source system and extend through the downstream devices at the load end.

2.14.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the commercial power company for fault current availability at the site.

2.14.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.14.4 Fault Current Analysis

2.14.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, and IEEE 399.

2.14.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.14.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.14.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.14.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided. Software model files used for study, calculation, and analysis shall be provided to the Contracting Officer Representative (COR) or Base Civil Engineer (for Air Force projects). For Air Force projects, the analysis shall be performed using Easy Power analysis software. Contractor shall not be required to obtain and provide software licenses to the Government unless it is explicitly requested in contract drawings or specifications.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Submit procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment. Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

Prior to field tests, submit the proposed test plan consisting of complete field test procedure, tests to be performed, test equipment required, and tolerance limits, and complete testing and verification of the ground fault protection equipment, where used. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 3 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

Visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, verify operating voltages on closing and tripping coils. Verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.3.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Submit data including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

-- End of Section --

SECTION 26 32 14.00 10

DIESEL-GENERATOR SET, STATIONARY 15-300 KW, STANDBY APPLICATIONS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASME INTERNATIONAL (ASME)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.1	(2014; INT 1-47) Power Piping
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM D975	(2014a) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1	(2000; R 2005) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE 120	(1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2014) Motors and Generators
NEMA PB 1	(2011) Panelboards
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 110	(2013) Standard for Emergency and Standby Power Systems
NFPA 30	(2015) Flammable and Combustible Liquids Code
NFPA 37	(2015) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 99	(2015) Health Care Facilities Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2011) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006; Reprint Jul 2011) Standard for Battery Chargers for Charging Engine-Starter Batteries

UL 489 (2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL 891 (2005; Reprint Oct 2012) Switchboards

1.2 SYSTEM DESCRIPTION

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine generator set shall satisfy the requirements specified in the Engine Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter, mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Sets shall be assembled and attached to the base prior to shipping. Set components shall be environmentally suitable for the locations shown and shall be the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating.

1.2.1 Engine-Generator Parameter Schedule

ENGINE GENERATOR PARAMETER SCHEDULE	
Service Load	kVAas indicated in contract drawings/documents
Power Factor	0.8 lagging
Motor Starting kVA (maximum)	kVA as indicated in contract drawings/documents
Maximum Speed	1800 rpm
Engine-Generator Application	stand-alone
Engine Cooling Type	water/ethylene glycol
Heat Exchanger Type	fin-tube
Frequency Bandwidth percent steady state	±0.4
Governor Type	Droop
Frequency Regulation (droop) (No load to full load)	3 percent max.
Frequency Bandwidth percent (steady state)	±0.4

ENGINE GENERATOR PARAMETER SCHEDULE	
Voltage Regulation (No load to full load)	± 2 percent (max.)
Voltage Bandwidth (steady state)	±2 percent
Frequency	60 Hz
Voltage	as indicated in contract drawings/documents
Phases	3 Phase, Wye
Minimum Generator Reactance	0.12 percent Subtransient
Nonlinear Loads	kVA as indicated in contract drawings/documents
Max Step Load Increase	100 percent of Service Load at 0.8 PF
Max Step Load Decrease (w/o shutdown)	100 percent of Service Load at 0.8 PF
Max Time to Start and be Ready to Assume Load	10 seconds
Max Summer Indoor Temp (Prior to Genset Operation)	as indicated in contract drawings/documents
Min Winter Indoor Temp (Prior to Genset Operation)	as indicated in contract drawings/documents
Min Winter Indoor Temp	as indicated in contract drawings/documents
Max Allowable Heat Transferred To Engine Generator Space at Rated Output Capacity	as specified
Max Summer Outdoor Temp (Ambient)	as indicated in contract drawings/documents
Min Winter Outdoor Temp (Ambient)	as indicated in contract drawings/documents
Installation Elevation	as indicated in contract drawings/documents

1.2.2 Output Capacity

Provide each generator set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity shall also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

1.2.3 Power Rating

Standby ratings shall be in accordance with EGSA 101P.

1.2.4 Engine Generator Set Enclosure

The engine generator set enclosure shall be corrosion resistant, fully weather resistant, contain all set components, and provide ventilation to permit operation at rated load under secured conditions. Provide doors for access to all controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure shall be capable of being removed without disassembly of the engine-generator set or removal of components other than exhaust system. The enclosure shall reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

1.2.5 Vibration Isolation

1.2.5.1 Vibration Limitations

The maximum engine-generator set vibration in the horizontal, vertical and axial directions shall be limited to 0.15 mm (6 mils) (peak-peak RMS), with an overall velocity limit of 24 mm/seconds (0.95 inches/seconds) RMS, for all speeds through 110 percent of rated speed. The engine-generator set shall be provided with vibration-isolation in accordance with the manufacturer's standard recommendation. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.2.5.2 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.2.5.3 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.2.6 Reliability and Durability

Submit documentation which cites engines and generators in similar service to demonstrate compliance with the requirements of this specification. Certification does not exclude annual technological improvements made by a manufacturer in the basic standard model set on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets all the performance requirements of this specification. For each different set, 2 like sets shall have performed satisfactorily in a stationary power application, independent and separate from the physical location of the manufacturer's and assembler's facilities, for a minimum of 2 consecutive years without any failure to start, including periodic exercise. The certification shall state that for the set proposed to meet this specification, there were no failures resulting in downtime for repairs in excess of 72 hours or any failure due to overheating during 2 consecutive years of service.

Like sets are of the same model, speed, bore, stroke, number and configuration of cylinders, and output power rating. Like generators are of the same model, speed, pitch, cooling, exciter, voltage regulator and output power rating. A list shall be provided with the name of the installations, completion dates, and name and telephone number of a point of contact.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings; G
Acceptance; G

SD-03 Product Data

Manufacturer's Catalog
Instructions
Experience
Field Engineer
Site Welding
General Installation
Site Visit

SD-05 Design Data

Sound Limitations
Generator
Integral Main Fuel Storage Tank
Power Factor
Heat Exchanger
Time-Delay on Alarms
Cooling System
Vibration Isolation

SD-06 Test Reports

Performance Tests
Onsite Inspection and Tests; G

SD-07 Certificates

Vibration Isolation
Prototype Tests
Reliability and Durability
Emissions
Sound limitations
Current Balance
Materials and Equipment
Factory Inspection and Tests
Inspections
Cooling System

SD-10 Operation and Maintenance Data

Operation Manual
Maintenance Manual
Extra Materials

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, the design, fabrication and installation shall conform to the code.

1.4.2 Site Welding

Weld structural members in accordance with Section 05 05 23 WELDING, STRUCTURAL. For all other welding, qualify procedures and welders in accordance with ASME BPVC SEC IX.

a. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1.

b. Welder qualification tests shall be performed for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests. The qualification tests shall be performed at the work site if practical.

c. The welder or welding operator shall apply the assigned personal symbol near each weld made as a permanent record

d. Submit a letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their qualifications symbols.

1.4.3 Experience

Each component manufacturer shall have a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacture/assembler shall have a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.4 Field Engineer

The engine-generator set manufacturer or assembler shall furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer shall have attended the engine-generator manufacturer's training courses on installation and operation and maintenance for engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.5 Seismic Requirements

Seismic requirements shall be in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.4.6 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments including anchor bolt template and recommended clearances for maintenance and operation.

b. Starting system.

c. Fuel system.

d. Cooling system.

e. Exhaust system.

f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.

g. Lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices.

i. The safety system, including wiring schematics.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and all instrumentation.

k. Panel layouts.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set rigging points and lifting instructions.

1.5 DELIVERY, STORAGE AND HANDLING

Properly protect materials and equipment in accordance with the manufacturers recommended storage procedures, before, during, and after installation. Protect stored items from the weather and contamination. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 MAINTENANCE SERVICE

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.6.1 Operation Manual

Provide one hard copy & one digital copy (.pdf - text searchable) of the operation manual. Hard copy shall be in 216 by 279 mm (8-1/2 by 11 inch) three-ring binder. Sections in the hard copy of the manual shall be separated by heavy plastic dividers with tabs which identify the material in the section. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Hard copy of drawing shall be placed in 216 by 279 mm (8-1/2 by 11 inch) plastic pockets with reinforced holes and with the title block visible. The manual shall include:

a. Step-by-step procedures for system startup, operation, and shutdown;

b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;

c. Procedures for interface and interaction with related systems to include automatic transfer switches.

1.6.2 Maintenance Manual

Provide one hard copy & one digital copy (.pdf - text searchable) of the maintenance manual. Hard copy shall be in 216 by 279 mm (8-1/2 by 11 inch) three-ring binder. Sections in the hard copy of the manual shall be separated by a heavy plastic divider with tabs. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Hard copy of drawings shall be folded, with the title block visible, and placed in plastic pockets with reinforced holes. The manual shall include:

a. Procedures for each routine maintenance item. Procedures for troubleshooting. Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. The manufacturer's recommended maintenance schedule.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components listed in paragraph GENERAL REQUIREMENTS.

d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.6.3 Extra Materials

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset shall be provided for each electronic governor when required to indicate and/or change governor response settings. Supply two complete sets of filters in a suitable storage box in addition to filters replaced after testing.

PART 2 PRODUCTS

2.1 NAMEPLATES

Each major component of this specification shall have the manufacturer's name, type or style, model or serial number, and rating number on a plate secured to the equipment. As a minimum, nameplates shall be provided for: Engines; Relays; Generators; Day tanks; Transformers (CT & PT); Regulators; Pumps and pump motors; Governors; Generator Breaker; Economizers; Heat exchangers (other than base-mounted).

Engines	Relays
Generators	Day tanks
Transformers (CT & PT)	Regulators
Pumps and pump motors	Governors
Generator Breaker	Economizers
Heat exchangers (other than base-mounted)	

Where the following equipment is provided as a standard component by the diesel-engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Exhaust mufflers	Exciters
Switchgear	Silencers
Battery	

2.2 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel during normal operation shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed so that proper operation of the equipment is not impaired.

2.3 MATERIALS AND EQUIPMENT

Materials and equipment shall be as specified. Submit a letter certifying that where materials or equipment are specified to comply with requirements of UL, or other standards, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.3.1 Circuit Breakers, Low Voltage

UL 489 and UL 489.

2.3.2 Filter Elements (Fuel-oil, Lubricating-oil, and Combustion-air)

Manufacturer's standard.

2.3.3 Instrument Transformers

NEMA/ANSI C12.11.

2.3.4 Pipe (Fuel/Lube-oil, Compressed-Air, Coolant and Exhaust)

ASTM A53/A53M, ASTM A106/A106M or ASTM A135/A135M, steel pipe. Pipe smaller than 50 mm (2 inches) shall be Schedule 80. Pipe 50 mm (2 inches) and larger shall be Schedule 40.

2.3.5 Pipe Flanges and Fittings

a. Pipe Flanges and Flanged Fittings: ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

b. Pipe Welding Fittings: ASTM A234/A234M, Grade WPB or WPC, Class 150, or ASME B16.11, 1360.7 kg (3000 lb).

c. Threaded Fittings: ASME B16.3, Class 150.

d. Valves: MSS SP-80, Class 150.

e. Gaskets: Manufacturers Standard.

2.3.6 Pipe Hangers

MSS SP-58 and MSS SP-69.

2.3.7 Electrical Enclosures

2.3.7.1 General

NEMA ICS 6.

2.3.7.2 Panelboards

NEMA PB 1.

2.3.8 Electric Motors

Electric motors shall conform to the requirements of NEMA MG 1. Motors shall have sealed ball bearings, a maximum speed of 1800 rpm and integral automatic or manual reset thermal overload protectors. Motors used indoors shall have drip proof frames; those used outside shall be totally enclosed. AC motors larger than 373 W (1/2 Hp) shall be of the squirrel cage induction type for standard voltage, 60 Hz three phase power. AC motors 373 W (1/2 Hp) or smaller, shall be for standard voltage, 60 Hz, single phase power.

2.3.9 Motor Controllers

Motor controllers and starters shall conform to the requirements of NFPA 70 and NEMA ICS 2.

2.4 ENGINE

Each engine shall operate on No. 2-D diesel conforming to ASTM D975, shall be designed for stationary applications and shall be complete with ancillaries. The engine shall be a standard production model described in the manufacturer's catalog data, which describes and depicts each engine-generator set and all ancillary equipment in sufficient detail to demonstrate specification compliance. The engine shall be naturally aspirated, scavenged, supercharged or turbocharged. The engine shall be two- or four-stroke-cycle and compression-ignition type. The engine shall be vertical inline, V-, or opposed-piston type, with a solid cast block or individually cast cylinders. The engine shall have a minimum of two cylinders. Opposed-piston type engines shall have no less than four cylinders. Each block shall have a coolant drain port. Each engine shall be equipped with an overspeed sensor.

2.5 FUEL SYSTEM

The fuel system for each engine generator set shall conform to the requirements of NFPA 30 and NFPA 37 and contain the following elements.

2.5.1 Pumps

2.5.1.1 Main Pump

Each engine shall be provided with an engine driven pump. The pump shall supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. The fuel flow rate shall be based on meeting the load requirements and all necessary recirculation.

2.5.1.2 Auxiliary Fuel Pump

Auxiliary fuel pumps shall be provided to maintain the required engine fuel pressure, either required by the installation or indicated on the drawings. The auxiliary pump shall be driven by a dc electric motor powered by the starting/station batteries. The auxiliary pump shall be automatically actuated by a pressure detecting device.

2.5.2 Filter

A minimum of one full flow fuel filter shall be provided for each engine. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.5.3 Relief/Bypass Valve

A relief/bypass valve shall be provided to regulate pressure in the fuel supply line, return excess fuel to a return line, and prevent the build-up of excessive pressure in the fuel system.

2.5.4 Integral Main Fuel Storage Tank

Each engine shall be provided with an integral main fuel tank, unless otherwise indicated. Each tank shall be factory installed and provided as an integral part of the diesel generator manufacturer's product. Each tank shall be provided with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. A fuel return line cooler shall be provided as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank shall be below the flash point of the fuel. Each engine-generator set provided with weatherproof enclosures shall have its tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.5.4.1 Capacity

Each tank shall have capacity as shown at 100 percent rated load without being refilled.

2.5.4.2 Local Fuel Fill

Each local fuel fill port on the day tank shall be provided with a screw-on cap.

2.5.4.3 Fuel Level Controls

Each tank shall have a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.5.4.4 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors shall be provided with an internal or external factory installed valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection shall be welded pipe.2.6
LUBRICATION

Each engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. Each system shall be pressurized by engine-driven oil pumps. Each system shall be furnished with a relief valve for oil pressure regulation (for closed systems) and a dip-stick for oil level indications. The crankcase shall be vented in accordance with the manufacturer's recommendation except that it shall not be vented to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, shall be piped to vent to the outside. The system shall be readily accessible for service such as draining, refilling, etc. Each system shall permit addition of oil and have oil-level indication with the set operating. The system shall utilize an oil cooler as recommended by the engine manufacturer.

2.6.1 Filter

One full-flow filter shall be provided for each pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.6.2 Lube-Oil Sensors

Each engine shall be equipped with lube-oil pressure sensors. Pressure sensors shall be located downstream of the filters and provide signals for required indication and alarms.

2.7 COOLING SYSTEM

Each engine cooling system shall operate automatically while the engine is running. Each cooling system shall be sized for the maximum summer outdoor design temperature and site elevation. Water-cooled system coolant shall use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across the engine shall be no more than that recommended and submitted.

a. The maximum and minimum allowable inlet temperatures of the coolant fluid.

b. The maximum allowable temperature rise in the coolant fluid through the engine.

c. The minimum allowable inlet fuel temperature.

2.7.1 Coolant Pumps

Coolant pumps shall be the centrifugal type. Each engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers.

2.7.2 Heat Exchanger

Each heat exchanger shall be of a size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted in accordance with paragraph SUBMITTALS for the maximum summer outdoor design temperature and site elevation. Each heat exchanger shall be corrosion resistant, suitable for service in ambient conditions of application. Submit manufacturers data to quantify heat rejected to the space with the engine generator set at rated capacity.

2.7.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosive resistant film providing that corrosion measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via oversizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 48 kPa gauge (7 psi). Each heat exchanger shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least two tapped holes. One tapped hole in the heat exchanger shall be equipped with a drain cock, the rest shall be plugged.

2.7.3 Ductwork

Ductwork shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS except that a flexible connection shall be used to connect the duct to the diesel engine radiator. Material for the connection shall be wire-reinforced glass. The connection shall be rendered practically airtight.

2.7.4 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high indication and alarms.

2.8 SOUND LIMITATIONS

The noise generated by the diesel generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 7 meters (22.9 feet) at 45 degrees apart in all directions. Submit data to demonstrate compliance with these sound limitation requirements. Also submit certification from the manufacturer stating that the sound emissions meet the specification.

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
31	87
63	87
125	77
250	70
500	64
1000	61
2000	60
4000	60
8000	62

2.9 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. Silencer shall be capable of reducing the noise level at the air intake to a point below the maximum acceptable levels specified in paragraph SOUND LIMITATIONS. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be rubber.

2.10 EXHAUST SYSTEM

The system shall be separate and complete for each engine. Piping shall be supported so as to minimize vibration. Where a V-type engine is provided, a V-type connector with necessary flexible sections and hardware shall connect the engine exhaust outlets.

2.10.1 Flexible Sections and Expansion Joints

A flexible section at each engine and an expansion joint at each muffler shall be provided. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for diesel-engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Expansion and flexible elements shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.10.2 Exhaust Muffler

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for mounting as indicated on contract drawings/documents. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature 204 degrees C (400 degrees F) resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.10.3 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a condensate trap and drain valve. Changes in direction shall be long-radius. Exhaust piping, mufflers and silencers installed inside any building shall be insulated in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Vertical exhaust piping shall be provided with a hinged, gravity operated, self-closing, rain cover.

2.11 EMISSIONS

The finished installation shall comply with national, provincial and local regulations and restrictions regarding the limits of emissions, as listed herein:

Submit a certification from the engine manufacturer stating that the engine exhaust emissions meet federal, state, and local regulations and restrictions specified. At a minimum, this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.12 STARTING SYSTEM

The starting system for standby engine generator sets used in emergency applications shall be in accordance with NFPA 99 and NFPA 110 and as follows.

2.12.1 Controls

An engine control switch shall be provided with functions including: run/start (manual), off/reset, and automatic mode. Start-stop logic shall be provided for adjustable cycle cranking and cool down operation. The logic shall be arranged for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR SET SYSTEM OPERATION. Electrical starting systems shall be provided with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.12.2 Capacity

The starting system shall be of sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system shall be capable of providing a minimum of three cranking periods with 15-second intervals between cranks. Each cranking period shall have a maximum duration of 15 seconds.

2.12.3 Functional Requirements

Starting system shall be manufacturers recommended dc system utilizing a negative circuit ground. Starting motors shall be in accordance with SAE ARP892.

2.12.4 Battery

A starting battery system shall be provided and shall include the battery, battery rack, intercell connectors, and spacers. The battery shall be in accordance with SAE J537. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces specified. The battery shall be lead-acid type, with sufficient capacity, at the minimum outdoor winter temperature specified to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.12.5 Battery Charger

A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize charging rate for recharging fully depleted batteries within 24 hours and a float charge rate for maintaining the batteries in prime starting condition. An ammeter shall be provided to indicate charging rate. A timer shall be provided for the equalize charging rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

2.12.6 Starting Aids

The manufacturer shall provide one or more of the following methods to assist engine starting.

2.12.6.1 Glow Plugs

Glow plugs shall be designed to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of -32 degrees C (-25 degrees F).

2.12.6.2 Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified.

2.13 GOVERNOR

Each engine shall be provided with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. The governor shall be configured for safe manual adjustment of the speed/frequency during operation of the engine generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of zero to 100 percent of rated capacity. Droop governors shall maintain the midpoint of the frequency bandwidth linearly for steady-state loads over the range of zero to 100 percent of rated output capacity, with 3 percent droop.

2.14 GENERATOR

Each generator shall be of the synchronous type, one or two bearing, conforming to NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Insulation shall be Class H. Generator design shall protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 100 percent. Generator ancillary equipment shall meet the short circuit requirements of NEMA MG 1. Frames shall be the drip-proof type. Submit each generator KW rating and short circuit capacity (both symmetric and asymmetric).

2.14.1 Current Balance

At 100 percent rated load, and load impedance equal for each of the three phases, the permissible current difference between any two phases shall not exceed 2 percent of the largest current on either of the two phases. Submit manufacturer's certification that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.14.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated load, the difference in line-to-neutral voltage among the three phases shall not exceed 1 percent of the average line-to-neutral voltage. For a single-phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other two phases, the maximum simultaneous difference in line-to-neutral voltage between the phases shall not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement shall be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.14.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced full rated load at 0.8 power factor shall not exceed 10 percent. The RMS of all harmonics shall be less than 5.0 percent and that of any one harmonic less than 3.0 percent at full rated load. Each engine-generator shall be designed and configured to meet the total harmonic distortion limits of IEEE 519.

2.15 EXCITER

The generator exciter shall be of the brushless type. Semiconductor rectifiers shall have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 40 degrees C (104 degrees F) ambient. The exciter and regulator in combination shall maintain generator-output voltage within the limits specified.

2.16 VOLTAGE REGULATOR

Each generator shall be provided with a solid-state voltage regulator, separate from the exciter. The regulator shall maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Regulator shall be configured for safe manual adjustment of the engine generator voltage output without special tools, during operation from 90 to 110 percent of the rated voltage over the steady state load range of zero to 100 percent of rated output capacity. Regulation drift shall not exceed plus or minus 0.5 percent for an ambient temperature change of 20 degrees C (36 degrees F). The voltage regulator shall have a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.17 GENERATOR PROTECTION

Short circuit and overload protection for the generator shall be provided. The generator circuit breaker (IEEE Device 52) ratings shall be consistent with the generator rated voltage and frequency, with continuous, short circuit and interrupting current ratings to match the generator capacity. The manufacturer shall determine the short circuit current interrupting rating of the breaker. The breaker shall be engine generator base mounted by the engine-generator set manufacturer. Molded case breakers shall be provided with shunt trip. Surge protection shall be provided for each phase of the generator, to be mounted at the generator terminals.

2.17.1 Panelboards

Panelboards shall be metal-enclosed, general purpose, 3-phase, 4-wire, 600 volt rated, with neutral bus and continuous ground bus, conforming to NEMA PB 1 and UL 891. Neutral bus and ground bus capacity shall be full capacity. Enclosure designs, construction, materials and coatings shall be suitable for the application and environment. Bus continuous current rating shall be at least equal to the generator rating and correspond to UL listed current ratings specified for panelboards and switchboards. Current withstand rating (short circuit rating) shall match the generator capacity. Buses shall be copper.

2.17.2 Devices

Switches, circuit breakers, switchgear, fuses, relays, and other protective devices shall be as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.18 SAFETY SYSTEM

Devices, wiring, remote panels, local panels, etc., shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgement and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be configured so that loss of any monitoring device shall be dealt with as an alarm on that system element.

2.18.1 Audible Signal

The audible alarm signal shall sound at a frequency of 60 Hz at a volume of 100 dB at 3.1 m (10 feet). The sound shall be continuously activated upon alarm and silenced upon acknowledgment. Signal devices shall be located as shown.

2.18.2 Visual Alarm Signal

The visual alarm signal shall be a panel light. The light shall be normally off, activated to be blinking upon alarm. The light shall change to continuously light upon acknowledgement. If automatic shutdown occurs, the display shall maintain activated status to indicate the cause of failure and shall not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms shall be red; all other alarms shall be amber.

2.18.3 Alarms and Action Logic

2.18.3.1 Shutdown

Simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers shall be accomplished.

2.18.3.2 Problem

Activation of the visual signal shall be accomplished.

2.18.4 Local Alarm Panel

Provide a local alarm panel with the following shutdown and alarm functions as indicated.

Device/ Condition/ Function	What/Where/ Sizes
Shutdowns W/Alarms	
High engine temperature	Automatic/ jacket water/ cylinder

Device/ Condition/ Function	What/Where/ Sizes
Low lube-oil pressure	Automatic/ pressure/ level
Overspeed shutdown $ alarm	110% ± 2% of rated speed
Overcrank failure to start	Automatic/ Failure to start
Air shutdown damper (200-600 kW)	When used
Day tank overfill limit indication & transfer pump shutdown (95% volume)	Automatic/ Day Tank/ Level
Red emergency stop switch	Manual switch
Alarms	
Low lube-oil pressure	Pressure/ level
Low fuel level	Main tank, 3 hours remaining
High fuel level	Integral Main Fuel Storage Tank 95% Volume
Low coolant	Jacket water

Device/ Condition/ Function	What/Where/ Sizes
Pre-high temperature	Jacket water/ cylinder
Pre-low lube-oil pressure	
High battery voltage	
Low battery voltage	
Battery charger AC failure	AC supply not available
Control switch not in AUTO	
Low starting air pressure	
Low starting hydraulic pressure	
Symbol Key	
SD	Shut Down
CP	On Control Panel
VA	Visual Alarm
AA	Audible Alarm
O	Optional

2.18.5 Time-Delay on Alarms

For startup of the engine-generator set, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. The lube-oil time-delay device shall return its alarm to normal status after the engine starts. The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts.

Submit the magnitude of monitored values which define alarm or action setpoints, and the tolerance (plus and/or minus) at which the device activates the alarm or action.

2.18.6 Remote Alarm Panel

A remote alarm panel shall be provided as indicated.

Device/ Condition/ Function	What/Where/Size
Remote annunciator panel	Battery powered
Loads on genset	
Battery charger malfunction	
Low lube-oil	Pressure/level
Low Temperature	Jacket water
High Temperature	Jacket water/cylinder
Low fuel level	Main tank, 3 hr remaining
Overcrank	Failure to start
Overspeed	
Pre-high temperature	Jacket water/cylinder
Control switch not in	
AUTO	
Common alarm contacts for local & remote common alarm	
Audible alarm silencing switch	
Air shutdown damper	When used
Common fault alarm	
Symbology Key	
X	Required
SD	Shut Down
CP	On Control Panel
VA	Visual Alarm

Device/ Condition/ Function	What/Where/Size
AA	Audible Alarm
O	Optional

2.19 ENGINE GENERATOR SET CONTROLS AND INSTRUMENTATION

Devices, wiring, remote panels, local panels, etc., shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions.

2.19.1 Controls

A local control panel shall be provided with controls as indicated in accordance with NFPA 110 level 1 and as follows mounted either on or adjacent to the engine generator set as indicated. A remote control panel shall be provided with devices as indicated.

Device/ Condition/ Function	MFG Offering
Controls	
Switch: run/start - off/set - auto	CP/STD
Emergency stop switch & alarm	CP/STD
Lamp test/indicator test	CP/STD
Common alarm contacts/ fault relay	CP/O
Panel lighting	CP/STD
Audible alarm & silencing/reset switch	
Voltage adjust for voltage regulator	CP/STD
Pyrometer display w/selector switch	
Remote emergency stop switch	

Device/ Condition/ Function	MFG Offering
Controls	
Remote fuel shutoff switch	
Remote lube-oil shutoff switch	

2.19.2 Engine Generator Set Metering and Status Indication

A local panel shall be provided with devices as indicated in accordance with NFPA 110 level 1 and as follows mounted either on or adjacent to the engine generator set as indicated. A remote control panel shall be provided with devices as indicated.

Device/ Condition/ Function	MFG Offering
Genset Status & Metering	
Genset supplying load	CP VAO
System ready	CP/STD
Engine oil pressure	CP/STD
Engine coolant temperature	CP/STD
Engine RPM (Tachometer)	CP/STD
Engine run hours	CP/STD
Pyrometer display w/selector switch	
AC volts (generator), 3-phase	CP/STD
AC amps (generator), 3-phase	CP/STD
Generator frequency	CP/STD
Phase selector switches (amps & volts)	CP/STD
Watts/kW	CP/VA-O
Voltage Regulator Adjustment	
Symbology Key:	
CP	
VA	
AA	

Device/ Condition/ Function	MFG Offering
O	
STD	

2.20 PANELS

Each panel shall be of the type necessary to provide specified functions. Panels shall be mounted on the engine generator set base by vibration/shock absorbing type mountings. Instruments shall be mounted flush or semiflush. Convenient access to the back of instruments shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function as indicated. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. Panels except the remote alarm panel can be combined into a single panel.

2.20.1 Enclosures

Enclosures shall be designed for the application and environment, conforming to NEMA ICS 6, and provided with locking mechanisms which are keyed alike.

2.20.2 Analog

Analog electrical indicating instruments shall be in accordance with ANSI C39.1 with semiflush mounting. Switchgear, and control-room panel-mounted instruments shall have 250 degree scales with an accuracy of not less than 1 percent. Unit-mounted instruments shall be the manufacturer's standard with an accuracy of not less than 2 percent. The instrument's operating temperature range shall be minus 20 to plus 65 degrees C (minus 4 to plus 130 degrees F). Distorted generator output voltage waveform of a crest factor less than 5 shall not affect metering accuracy for phase voltages, hertz and amps.

2.20.3 Electronic

Electronic indicating instruments shall be true RMS indicating, 100 percent solid state, microprocessor controlled to provide all specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy shall be not less than 2 percent for unit mounted devices and 1 percent for control room, panel mounted devices, throughout a temperature range of minus 20 to plus 65 degrees C (minus 4 to plus 130 degrees F). Data display shall utilize LED or back lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be 13 mm (1/2 inch).

2.20.4 Parameter Display

Indication or readouts of the lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and coolant temperature.

2.20.5 Exerciser

The exerciser shall be in accordance with Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.21 SURGE PROTECTION

Electrical and electronic components shall be protected from, or designed to withstand the effects of surges from switching and lightning.

2.22 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Fully automatic operation shall be provided for the following operations: engine-generator set starting and source transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; and stopping of each engine-generator set after cool down. Devices shall automatically reset after termination of their function.

2.22.1 Automatic Transfer Switch

Automatic transfer switches shall be in accordance with Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.22.2 Monitoring and Transfer

Devices shall be provided to monitor voltage and frequency for the normal power source and each engine generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Functions, actuation, and time delays shall be as described in Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.23 MANUAL ENGINE-GENERATOR SET SYSTEM OPERATION

Complete facilities shall be provided for manual starting and testing of each set without load, loading and unloading of each set.

2.24 BASE

The base shall be constructed of steel. The base shall be designed to rigidly support the engine-generator set, ensure permanent alignment of all rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment will be maintained during shipping and normal operation. The base shall permit skidding in any direction during installation and shall be provided with suitable holes for foundation bolts. The base shall also withstand and mitigate the effects of synchronous vibration of the engine and generator, and shall be provided with suitable holes for anchor bolts and jacking screws for leveling.

2.25 THERMAL INSULATION

Thermal insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.26 PAINTING AND FINISHING

The engine-generator set shall be cleaned, primed and painted in accordance with the manufacturer's standard color and practice.

2.27 FACTORY INSPECTION AND TESTS

Perform factory inspection and tests on each engine-generator set proposed to meet this specification section. Inspections shall be completed and necessary repairs made prior to testing. Inspectors shall look for leaks, looseness, defects in components, and proper assembly. Factory tests shall be NEMA MG 1 routine tests and the manufacturers routine tests. Submit a certification that each engine generator set passed the factory tests and inspections and a list of the test and inspections.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform a Site Visit to verify details of the work. Submit a site visit letter stating the date the site was visited and listing discrepancies found and advise the Contracting Officer in writing of any discrepancies before performing any work.

3.2 GENERAL INSTALLATION

Submit a complete copy of the manufacturer's installation procedures. A detailed description of the manufacturer's recommended break-in procedure.

Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Configure installation of pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

3.3.1 General

Piping shall be welded. Connections at valves shall be flanged. Connections at equipment shall be flanged except that connections to the diesel engine may be threaded if the diesel-engine manufacturer's standard connection is threaded. Except as otherwise specified, flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to all equipment shall be made with flexible connectors. Pipes extending through the roof shall be properly flashed. Piping shall be installed clear of windows, doors, and openings to permit thermal expansion and contraction without damage to joints or hangers, and with a 13 mm (1/2 inch) drain valve at each low point.

3.3.2 Supports

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58 and MSS SP-69. Supports shall be spaced not more than 2.1 m (7 feet) on center for pipes 50 mm (2 inches) in diameter or less, not more than 3.6 m (12 feet) on center for pipes larger than 50 mm (2 inches) but no larger than 100 mm (4 inches), and not more than 5.2 m (17 feet) on center for pipes larger than 100 mm (4 inches) in diameter. Supports shall be provided at pipe bends or change of direction.

3.3.2.1 Ceiling and Roof

Exhaust piping shall be supported with appropriately sized type 41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized type 1 clevis and threaded rods.

3.3.2.2 Wall

Wall supports for pipe shall be made by suspending the pipe from appropriately sized type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.3 Flanged Joints

Flanges shall be Class 125 (125 pound) type, drilled, and of the proper size and configuration to match equipment and diesel-engine connections. Gaskets shall be factory cut in one piece 1.6 mm (1/16 inch) thick.

3.3.4 Cleaning

After fabrication and before assembly, piping interiors shall be manually wiped clean of all debris.

3.3.5 Pipe Sleeves

Pipes passing through construction such as ceilings, floors, or walls shall be fitted with sleeves. Each sleeve shall extend through and be securely fastened in its respective structure and shall be cut flush with each surface. The structure shall be built tightly to the sleeve. The inside diameter of each sleeve shall be 13 mm (1/2 inch), and where pipes pass through combustible materials, 25 mm (1 inch) larger than the outside diameter of the passing pipe or pipe covering.

3.4 ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, flexible fittings shall be provided for all conduit, cable trays, and raceways attached to engine-generator sets; metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set shall be flexible stranded conductor; and terminations of conductors on the engine generator set shall be crimp-type terminals or lugs. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed.

3.5 FIELD PAINTING

Field painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

3.6.1 Submittal Requirements

a. A letter giving notice of the proposed dates of all onsite inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the Contractor's proposed procedures for onsite tests including the test including the test plan and a listing of equipment necessary to perform the tests. Submission shall be at least 7 days prior to beginning tests.

c. One hard copy & one digital copy (.pdf - text searchable) of the onsite test data described below. Hard copy shall be in 216 by 279 mm (8-1/2 by 11 inch) 3-ring binders with a separate section for each test. Sections shall be separated by dividers with tabs. Data plots shall be full size 216 by 279 mm (8-1/2 by 11 inches) minimum, showing all grid lines, with full resolution.

   (1) A description of the procedures for onsite tests.

   (2) A list of equipment used, with calibration certifications.

   (3) A copy of measurements taken, with required plots and graphs.

   (4) The date of testing.

   (5) The parameters verified.

   (6) The condition specified for the parameter.

   (7) The test results, signed and dated.

   (8) A description of all adjustments made.

3.6.2 Test Conditions

3.6.2.1 Data

Measurements shall be made and recorded of parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, adjustments or replacements shall be made and the step repeated until satisfactory results are obtained. Unless otherwise indicated, data shall be taken during engine-generator set operation and recorded in 15 minute intervals and shall include: readings of engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Electrical measurements shall be performed in accordance with IEEE 120. Definitions and terms are in accordance with IEEE Stds Dictionary. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation shall be in accordance with IEEE 1.

3.6.2.2 Power Factor

Engine-generator set operating tests shall be made utilizing a load with the power factor specified in the engine generator set parameter schedule. Submit generator capability curve showing generator kVA output (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0.

3.6.2.3 Contractor Supplied Items

Provide all equipment and supplies required for inspections and tests including fuel, test instruments, and load banks at the specified power factors.

3.6.2.4 Instruments

Readings of panel gauges, meters, displays, and instruments, provided under this specification shall be verified during test runs by test instruments of precision and accuracy greater than the tested items. Test instrument accuracy shall be at least as follows: current, 1.5 percent; voltage, 1.5 percent; real power, 1.5 percent; reactive power, 1.5 percent; power factor, 3 percent; frequency, 0.5 percent. Test instruments shall be calibrated by a recognized standards laboratory within 90 days prior to testing.

3.6.2.5 Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance in authorized by the Contracting Officer. Field testing shall be performed in the presence of the Contracting Officer. Tests may be scheduled and sequenced in order to optimize run-time periods; however the following general order of testing shall be followed: Construction Tests; Inspections; Safety run Tests; and Performance Tests and Final Inspection.

3.6.3 Construction Tests

Individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer shall be performed prior to connection to the engine-generator set.

3.6.3.1 Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the fluid flowing out has no obvious sediment or emulsion.

b. Fuel piping which is external to the engine-generator set shall be tested in accordance with NFPA 30. All remaining piping which is external to the engine generator set shall be pressure tested with air pressure at 150 percent of the maximum anticipated working pressure, but in no case less than 1 MPa (150 psig), for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

3.6.3.2 Electrical Equipment Tests

a. Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the automatic transfer switch. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energizing. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

(1) R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters).

(2) (R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

(3) Each cable failing this test shall be repaired or replaced. The repaired cable shall be retested until failures have been eliminated.

b. Medium-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the distribution bus. After insulation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds or metallic shielding or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, except that 28kV and 35kV insulation test voltages shall be in accordance with either AEIC CS8 or AEIC CS8 as applicable, and shall not exceed the recommendations of IEEE 404 for cable joints and IEEE 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

c. Ground-Resistance Tests. The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

(1) Single rod electrode - 25 ohms.
(2) Multiple rod electrodes - 25 ohms.
(3) Ground mat - 25 ohms.

d. Circuit breakers and switchgear shall be examined and tested in accordance with manufacturer's published instructions for functional testing.

3.6.4 Inspections

The following inspections shall be performed jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented and submitted as a letter certifying that all facilities are complete and functional, that each system is fully functional, and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

1. Drive belts. (I)
2. Governor type and features. (I)
3. Engine timing mark. (I)
4. Starting motor. (I)
5. Starting aids. (I)
6. Coolant type and concentration. (D)
7. Radiator drains. (I)
8. Block coolant drains. (I)
9. Coolant fill level. (I)
10. Coolant line connections. (I)
11. Coolant hoses. (I)
12. Combustion air filter. (I)
13. Intake air silencer. (I)
14. Lube oil type. (D)
15. Lube oil drain. (I)
16. Lube-oil filter. (I)
17. Lube-oil-fill level. (I)
18. Lube-oil line connections. (I)
19. Lube-oil lines. (I)
20. Fuel type. (D)
21. Fuel-level. (I)
22. Fuel-line connections. (I)
23. Fuel lines. (I)
24. Fuel filter. (I)
25. Access for maintenance. (I)
26. Voltage regulator. (I)
27. Battery-charger connections. (I)
28. Wiring & terminations. (I)
29. Instrumentation. (I)
30. Hazards to personnel. (I)
31. Base. (I)
32. Nameplates. (I)
33. Paint. (I)
34. Exhaust system. (I)
35. Access provided to controls. (I)

36. Enclosure. (I)
37. Engine & generator mounting bolts (proper application). (I)

3.6.5 Safety Run Tests

a. Perform and record engine manufacturer's recommended prestart checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary, provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If temperature reading exceeds the value for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily seal their normal location on the engine and temporarily install temperature gauges in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 30 minutes at 100 percent of service load.

l. Verify proper operation of the governor and voltage regulator.

m. Verify proper operation and setpoints of gauges and instruments.

n. Verify proper operation of ancillary equipment.

o. Manually adjust the governor to increase engine speed past the overspeed limit. Record the RPM at which the engine shuts down.

p. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of rated load.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine. Record the results.

s. Attach a manifold to the engine oil system (at the oil sensor pressure port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. The engine's oil pressure sensor shall be moved from the engine to the manifold and its normal location on the engine temporarily sealed. The manifold shutoff valve shall be open and bleed valve closed.

t. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of service load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of service load. Record the maximum sound level in each frequency band at a distance of 22.9 m (75 feet) from the end of the exhaust and air intake piping directly along the path of intake and discharge horizontal piping; or at a radius of 10.7 m (35 feet) from the engine at 45 degrees apart in all directions for vertical piping. The measurements should comply with the paragraph SOUND LIMITATIONS. If a sound limiting enclosure is provided, the enclosure, the muffler, and intake silencer shall be modified or replaced as required to meet the sound requirements contained within this specification. If a sound limiting enclosure is not provided, the muffler and air intake silencer shall be modified or replaced as required to meet the sound limitations of this specification. If the sound limitations cannot be obtained by modifying or replacing the muffler and air intact silencer, notify the Contracting Officer and provide a recommendation for meeting the sound limitations.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.6 Performance Tests

Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data.

3.6.6.1 Continuous Engine Load Run Test

The engine-generator set and ancillary systems shall be tested at service load to: demonstrate reliability and durability (see paragraph RELIABILITY AND DURABILITY for submittal requirements); verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.). Stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Data taken at 15 minutes intervals shall include the following:

a. Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

b. Pressure: Lube-oil.

c. Temperature: Coolant, Lube-oil, Ambient.

(1) Perform and record engine manufacturer's recommended prestart checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

(2) Start the engine; make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

(3) Operate the engine generator-set for at least 2 hours at 75 percent of service load.

(4) Increase load to 100 percent of service load and operate the engine generator-set for at least 2 hours.

(5) Remove load from the engine-generator set.

3.6.6.2 Load Acceptance Test

Engine manufacturer's recommended prestart checks and inspections shall be performed and recorded. The engine shall be started, and engine manufacturer's after-starting checks and inspections made and recorded during a reasonable warm-up period. For the following steps, the output line-line and line-neutral voltages and frequency shall be recorded after performing each step instruction (after stabilization of voltage and frequency). Stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings.

a. Apply load in steps no larger than the Maximum Step Load Increase to load the engine-generator set to 100 of Service Load.

b. Verify that the engine-generator set responds to the load addition and that the output voltage returns to and stabilizes within the rated bandwidths.

3.6.7 Automatic Operation Tests for Stand-Alone Operation

The automatic loading system shall be tested to demonstrate automatic starting, and loading and unloading of each engine-generator set. The loads for this test shall utilize the actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

a. Ambient temperature (at 15 minute intervals).

b. Generator output current (before and after load changes).

c. Generator output voltage (before and after load changes).

d. Generator output frequency (before and after load changes.)

   (1) Initiate loss of the primary power source and verify automatic sequence of operation.

   (2) Restore the primary power source and verify sequence of operation.

   (3) Verify resetting of controls to normal.

3.7 ONSITE TRAINING

Conduct training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total 4 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance. The course instructions shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations such as oil change, oil filter change, and air filter change.

3.8 FINAL INSPECTION AND TESTING

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the maximum step load increase to 100 percent of service load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period. Perform the pre-test inspections and take necessary corrective actions.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Any corrective action shall be verified for effectiveness by running the engine for 4 hours at service load, then re-examining the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.9 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer shall furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.10 INSTRUCTIONS

Two sets of instructions shall be typed in 216 x 279 mm (8 1/2 x 11 inches) format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. The binders shall be placed as directed by the Contracting Officer. The instructions shall be in place prior to acceptance of the engine generator set installation. First set of instructions shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set of instructions shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

3.11 ACCEPTANCE

Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and after all defects in installation material or operation have been corrected.

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the diesel-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings.

-- End of Section --

SECTION 26 36 00.00 10

AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 602	(2007) Recommended Practice for Electric Systems in Health Care Facilities - White Book
IEEE C37.13	(2008; INT 1 2009; AMD 1 2012) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.90.1	(2012) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 10 Part 2	(2005) AC Transfer Equipment, Part 2: Static AC Transfer Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2010) Terminal Blocks
NEMA ICS 6	(1993; R 2011) Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 110	(2013) Standard for Emergency and Standby Power Systems
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1008	(2012; Reprint Apr 2013) Transfer Switch Equipment
UL 1066	(2012; Reprint Jul 2013) Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings
Installation

SD-03 Product Data

Equipment

SD-06 Test Reports

Testing

SD-10 Operation and Maintenance Data

Switching Equipment
Instructions

1.3 QUALITY ASSURANCE

1.3.1 Detail Drawings

Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Submit schematic, external connection, one-line schematic and wiring diagram of each ATS assembly. Device, nameplate, and item numbers shown in list of equipment and material shall appear on drawings wherever that item appears. Diagrams shall show interlocking provisions and cautionary notes, if any. Operating instructions shall be shown either on one-line diagram or separately. Unless otherwise approved, one-line and elementary or schematic diagrams shall appear on same drawing.

1.3.2 Switching Equipment

Upon request, manufacturer shall provide notarized letter certifying compliance with requirements of this specification, including withstand current rating (WCR). Submit evidence that ATS withstand current rating (WCR) has been coordinated with upstream protective devices as required by UL 1008. Submit an operating manual outlining step-by-step procedures for system startup, operation, and shutdown. Manual shall include manufacturer's name, model number, service manual, parts list, and brief description of equipment and basic operating features. Manufacturer's spare parts data shall be included with supply source and current cost of recommended spare parts. Manual shall include simplified wiring and control diagrams for system as installed.

1.4 SITE CONDITIONS

Seismic requirements shall be as specified in UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT as indicated. ATS shall be suitable for prolonged performance under following service conditions:

a. Altitude: as indicated on contract drawings/documents.

b. Relative Humidity: as indicated on contract drawings/documents.

c. Temperature: as indicated on contract drawings/documents.

d. Seismic Parameters: as indicated on contract drawings/documents.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide material and equipment which are standard products of a manufacturer regularly engaged in manufacturing the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit list of proposed equipment and material, containing a description of each separate item, and certificates of compliance showing evidence of UL listing and conformance with applicable NEMA standards. Such certificates are not required if manufacturer's published data, submitted and approved, reflect UL listing or conformance with applicable NEMA standards. The experience use shall include applications in similar circumstances and of same design and rating as specified ATS. Equipment shall be capable of being serviced by a manufacturer-authorized and trained organization that is, in the Contracting Officer's opinion, reasonably convenient to the site.

2.2 NAMEPLATE

Nameplate showing manufacturer's name and equipment ratings shall be made of corrosion-resistant material with not less than 3 mm (1/8 inch) tall characters. Nameplate shall be mounted to front of enclosure and shall comply with nameplate requirements of NEMA ICS 2.

2.3 AUTOMATIC TRANSFER SWITCH (ATS)

ATS shall be electrically operated and mechanically held in both operating positions. ATS shall be suitable for use in emergency systems or standby systems described in NFPA 70. ATS shall be UL listed. ATS shall be manufactured and tested in accordance with applicable requirements of IEEE C37.90.1, IEEE C37.13, IEEE C62.41.1, IEEE C62.41.2, IEEE 602, NEMA ICS 1, NEMA ICS 2, NEMA ICS 10 Part 2, UL 1008 and UL 1066. ATS shall conform to NFPA 110. To facilitate maintenance, manufacturer's instruction manual shall provide typical maximum contact voltage drop readings under specified conditions for use during periodic maintenance. Manufacturer shall provide instructions for determination of contact integrity. ATS shall be rated for continuous duty at specified continuous current rating. ATS shall be fully compatible and approved for use with BP/IS specified. BP/IS shall be considered part of ATS system. ATS shall have following characteristics:

a. Voltage: as indicated on contract drawings/documents.

b. Number of Phases: as indicated on contract drawings/documents.

c. Number of Wires: as indicated on contract drawings/documents.

d. Frequency: as indicated on contract drawings/documents.

e. Poles: as indicated on contract drawings/documents.

f. ATS WCR: Rated to withstand short-circuit current amperes, RMS symmetrical as indicated on contract drawings/documents.

g. Nonwelding Contacts: Rated for nonwelding of contacts when used with upstream feeder overcurrent devices shown and with available fault current specified.

h. Main and Neutral Contacts: Contacts shall have silver alloy composition. Neutral contacts shall have same continuous current rating as main or phase contacts, unless otherwise indicated on contract drawings/documents.

2.3.1 Override Time Delay

Provide adjustable time delay to override monitored source deviation from 0.5 to 6 seconds and factory set at 1 second. ATS shall monitor phase conductors to detect and respond to sustained voltage drop of 15 percent of nominal between any two source conductors and initiate transfer action to emergency source and start engine driven generator after set time period. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Dropout voltage shall be adjustable from 75 to 98 percent of pickup value and factory set at 85 percent of nominal.

2.3.2 Transfer Time Delay

Time delay before transfer to emergency power source shall be adjustable from 0 to 5 minutes and factory set at 0 minutes. ATS shall monitor frequency and voltage of emergency power source and transfer when frequency and voltage are stabilized. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal and factory set at 90 percent.

2.3.3 Return Time Delay

Time delay before return transfer to normal power source shall be adjustable from 0 to 30 minutes and factory set at 30 minutes. Time delay shall be automatically defeated upon loss or sustained undervoltage of emergency power source, provided that normal supply has been restored.

2.3.4 Engine Shutdown Time Delay

Time delay shall be adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

2.3.5 Exerciser

Provide a generator exerciser timer. Run times shall be user programmable. The generator exerciser shall be selectable between load transfer and engine run only, and shall have a fail-safe feature that will retransfer the ATS to normal during the exercise period.

2.3.6 Auxiliary Contacts

Two normally open and two normally closed auxiliary contacts rated at 15 amperes and 120 volts shall operate when ATS is connected to normal power source, and two normally open and two normally closed contacts shall operate when ATS is connected to emergency source.

2.3.7 Supplemental Features

ATS shall be furnished with the following:

a. Engine start contact.

b. Emergency source monitor.

c. Test switch to simulate normal power outage.

d. Voltage sensing. Pickup voltage adjustable from 85 to 100 percent of nominal; dropout adjustable from 75 to 98 percent of pickup.

e. Time delay bypass switch to override return time delay to normal.

f. Manual return-to-normal switch.

g. Means shall be provided in the ATS to insure that motor/transformer load inrush currents do not exceed normal starting currents. This shall be accomplished with either in-phase monitoring, time-delay transition, or load voltage decay sensing methods. If manufacturer supplies an in-phase monitoring system, the manufacturer shall indicate under what conditions a transfer cannot be accomplished. If the manufacturer supplies a time-delay transition system, the manufacturer shall supply recommendations for establishing time delay. If load voltage decay sensing is supplied, the load voltage setting shall be user programmable.

2.3.8 Operator

Manual operator conforming to UL 1008 shall be provided, and shall incorporate features to prevent operation by unauthorized personnel. ATS shall be designed for safe manual operation under full load conditions. If manual operation is accomplished by opening the door, then a dead-front shall be supplied for operator safety.

2.3.9 Override Switch

Override switch shall bypass automatic transfer controls so ATS will transfer and remain connected to emergency power source, regardless of condition of normal source. If emergency source fails and normal source is available, ATS shall automatically retransfer to normal source.

2.3.10 Green Indicating Light

A green indicating light shall supervise/provide normal power source switch position indication and shall have a nameplate engraved NORMAL.

2.3.11 Red Indicating Light

A red indicating light shall supervise/provide emergency power source switch position indication and shall have a nameplate engraved EMERGENCY.

2.4 BY-PASS/ISOLATION SWITCH (BP/IS)

2.4.1 Design

Bypass/isolation switch (BP/IS) shall permit load by-pass to either normal or emergency power source and complete isolation of associated ATS, independent of ATS operating position. BP/IS and associated ATS shall be products of same manufacturer and shall be completely interconnected and tested at factory and at project site as specified. BP/IS shall be manufactured, listed, and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH (ATS) and shall have electrical ratings that exceed or equal comparable ratings specified for ATS. Operating handles shall be externally operated and arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles within 5 seconds. The ATS shall have provisions for locking in the isolation position. Handle for manual operation shall be permanently attached to operating mechanism. BP/IS operation shall be accomplished without disconnecting switch load terminal conductors. Isolation handle positions shall be marked with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Indication shall be provided to show that ATS section is providing power to the load.

b. Indication shall be provided of ATS isolation. The ATS controls shall remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section shall be capable of functioning as a manual transfer switch to transfer the load to either power source. The ATS shall be capable of undergoing functional operation testing without service interruption. The ATS may also be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

2.4.2 Switch Construction

Bypass/isolation switch shall be constructed for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors. Contacts shall be as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. To facilitate maintenance, manufacturer shall provide instructions for determination of contact integrity. BP/IS and associated ATS shall be interconnected with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at WCR specified for associated ATS.

2.5 ENCLOSURE

ATS and accessories shall be installed in wall-mounted, free-standing, or floor-mounted, ventilated or unventilated NEMA ICS 6, NEMA Type as indicated, smooth sheet metal enclosure constructed in accordance with applicable requirements of UL 1066 and/or UL 1008. Intake vent shall be screened and filtered. Exhaust vent shall be screened. Door shall have suitable hinges, locking handle latch, and gasketed jamb. Thermostatically controlled heater shall be provided within enclosure to prevent condensation over temperature range stipulated in paragraph SERVICE CONDITIONS. Metal gauge shall be not less than No. 14. Enclosure shall be equipped with at least two approved grounding lugs for grounding enclosure to facility ground system using No. 4 AWG copper conductors. Factory wiring within enclosure and field wiring terminating within enclosure shall comply with NFPA 70. If wiring is not color coded, wire shall be permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing. Terminal block shall conform to NEMA ICS 4. Terminals shall be arranged for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, shall be pressure type suitable for termination of external copper conductors shown.

2.5.1 Construction

Enclosure shall be constructed for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components. Enclosure of ATS with BP/IS shall be constructed to protect personnel from energized BP/IS components during ATS maintenance.

2.5.2 Cleaning and Painting

Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Finish shall be manufacturer's standard material, process, and color and shall be free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 shall be acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.6 TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 5 days prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Reports shall be certified and dated and shall demonstrate that tests were successfully completed prior to shipment of equipment.

2.6.1 Factory Testing

A prototype of specified ATS shall be factory tested in accordance with UL 1008. In addition, factory tests shall be performed on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system.

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.6.2 Factory Test Reports

Manufacturer shall provide three certified copies of factory test reports.

2.7 FACTORY TESTING (MEDICAL FACILITIES)

The factory tests for ATS and By-Pass/Isolation switches used in medical facilities shall be conducted in the following sequence:

a. General
b. Normal
c. Overvoltage
d. Undervoltage
e. Overload
f. Endurance
g. Temperature Rise
h. Dielectric Voltage-Withstand
i. Contact Opening
j. Dielectric Voltage-Withstand (Repeated)
k. Withstand
l. Instrumentation and Calibration of High Capacity
m. Closing
n. Dielectric Voltage-Withstand (Repeated)
o. Strength of Insulating Base and Support

2.7.1 Viewing Ports

ATS and BP/IS switches shall be of draw-out construction. Viewing ports to inspect the contacts without requiring disassembly shall be provided.

2.7.2 Operating Handles

The operating handles shall be externally operated, and designed and constructed not to stop in an intermediate or neutral position during operation, but shall permit load by-pass and transfer switch isolation in no more than two manual operations which can be performed by one person in 5 seconds or less. The transfer speed will be independent of the operational speed of the switch handle or handles.

PART 3 EXECUTION

3.1 INSTALLATION

ATS shall be installed as shown and in accordance with approved manufacturer's instructions. Submit dimensioned plans, sections and elevations showing minimum clearances, weights, and conduit entry provisions for each ATS.

3.2 INSTRUCTIONS

Manufacturer's approved operating instructions shall be permanently secured to cabinet where operator can see them. One-line and elementary or schematic diagram shall be permanently secured to inside of front enclosure door. Submit one hard copy & one digital copy (.pdf - text searchable) of operating and maintenance manuals listing routine maintenance, possible breakdowns, repairs, and troubleshooting guide.

3.3 SITE TESTING

Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Advise Contracting Officer not less than 5 working days prior to scheduled date for site testing, and provide certified field test reports within 2 calendar weeks following successful completion of site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:

a. Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.

b. Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.

c. Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.

d. Low phase-to-ground voltage shall be simulated for each phase of normal source.

e. Operation and settings shall be verified for specified ATS features, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.

f. Manual and automatic ATS and BP/IS functions shall be verified.

-- End of Section --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 96	(2005; Reprint Sep 2013) Standard for Lightning Protection Components
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with NFPA 70, NFPA 780, and UL 96.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overall lightning protection system; G

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

Lightning protection system inspection certificate; G

Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing (one hard copy and one digital copy) for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams. For Air Force projects, shop drawing shall be prepared and stamped by a registered Professional Engineer.

1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Constructn, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with NFPA 780. Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to NFPA 780.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

2.1.2 Copper Only

Provide copper conductors, except where aluminum conductors are required for connection to aluminum equipment.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than 600 mm (24 inches) in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of copper-clad steel or solid copper conforming to conform to UL 467. Provide ground rods that are not less than 20 mm (3/4 inch) in diameter and 3000 mm (10 feet) in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Grounding Plates

Provide grounding plates made of copper-clad steel, iron, stainless steel or solid copper conforming to UL 96.

2.2.4 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.5 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780, including tie-ins to existing lightning protection systems. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1 Air Terminals

Use adhesive shoes with adhesive approved by the roof manufacturer when installing air terminals on "rubber" (EPDM) type roofs. In areas of snow or constant wind, ensure that a section of roofing material (minimum dimensional area of 92,900 square mm (1 square foot)) is first glued to the roof and then the air terminal is glued to it unless the roof manufacturer recommends another solution. Use a standing seam base for installation of air terminals on a standing seam metal roof that does not produce any roof penetrations.

3.1.1.2 Roof Conductors

Use adhesive shoes with adhesive approved by the roof manufacturer when installing roof conductors on "rubber" (EPDM) type roofs. Use a standing seam base for installation of roof conductors on a standing seam metal roof that does not produce any roof penetrations. Roof conductors are to be concealed within the ceiling cavities as much as practicable.

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by NFPA 780. Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC. Down conductors are to be concealed within the wall cavities.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less 3000 mm (10 feet). Set ground rods not less than 915 mm (3 feet) nor more than 2440 mm (8 feet), from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions when a ground ring electrode is not used. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than 3000 mm (10 feet) into the ground, a minimum of 3000 mm (10 feet) apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. 1/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than 915 mm (3 feet) nor more than 2440 mm (8 feet) from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of 765 mm (30 inches). Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

3.1.5 Grounding Plates

Provide a grounding plate for each down conductor. Set grounding plates not less than 915 mm (3 feet) nor more than 2440 mm (8 feet), from the structure foundation, and at least beyond the drip line for the facility. Grounding plate is to be buried as deeply in the existing dirt as local conditions allow, without exceeding 3000 mm (10 feet) in depth.

3.2 APPLICATIONS

3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least 1935 square mm (3 square inches).

3.2.2 Personnel Ramps and Covered Passageways

Place a down conductor and a driven ground at one of the corners where the ramp connects to each building or structure. Connect down conductor and driven ground to the ground ring electrode or nearest ground connection of the building or structure. Where buildings or structures and connecting ramps are clad with metal, separately bond the metal of the buildings and ramps to a down conductor as close to grade as possible.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system whenever the fence or gate is within 1830 mm (6 feet) of any part of the lightning protection system in accordance with ANSI C2.

3.3.2 Exterior Overhead Systems

Bond to the nearest down conductor as close to grade as possible. This includes overhead pipes, conduits, cable trays, or any other metallic objects on the exterior of the building that enter a building. In addition, bond pipes, conduits, and cable trays to any metallic objects (such as steel structural support of air handling units or cooling towers) that are within 1830 mm (6 feet).

3.4 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

3.5.2 Onsite Training

Conduct continuity and resistance test training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total of 4 hours of normal working time and shall start after contractor's system test is completed but prior to final acceptance. The course instructions shall cover visual inspection, continuity test, and ground resistance test.

-- End of Section --

SECTION 26 42 14.00 10

CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE)
08/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B418	(2012) Standard Specification for Cast and Wrought Galvanic Zinc Anodes
ASTM B843	(2013) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

NACE INTERNATIONAL (NACE)

NACE RP0193	(2001) External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms
NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0177	(2014) Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP0285	(2011) External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National

Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel

1.2 SYSTEM DESCRIPTION

Provide a complete, operating, sacrificial anode cathodic protection system in complete compliance with NFPA 70, with all applicable Federal, State, and local regulations and with the minimum requirements of this contract.

a. In addition to the minimum requirements of these specifications, construction of gas pipelines and associated cathodic protection systems shall be in compliance with 49 CFR 192, construction of hazardous liquid pipelines, including fuel pipelines, and associated cathodic protection systems shall be in compliance with 49 CFR 195, and construction and installation of underground fuel storage tanks and associated cathodic protection system shall be in compliance with 40 CFR 280.

b. The services required include planning, installation, adjusting and testing of a cathodic protection system, using sacrificial anodes for cathodic protection of the Water, Fire Protection, Force Main, Gas lines, their connectors and lines under the slab or floor foundation. The cathodic protection system shall include anodes, cables, connectors, corrosion protection test stations, and any other equipment required for a complete operating system providing the NACE criteria of protection as specified.

c. Submit an itemized list of equipment and materials including item number, quantity, and manufacturer of each item, within 30 days after receipt of notice to proceed. The list shall be accompanied by a description of procedures for each type of testing and adjustments, including testing of coating for thickness and holidays. Installation of materials and equipment shall not commence until this submittal is approved. Insulators are required whenever needed to insulate the pipes from any other structure. Any pipe crossing the indicated pipes shall have a test station. The cathodic protection shall be provided on Water, Fire Protection, Force Main, Gas pipes.

d. Submit proof that the materials and equipment furnished under this section conform to the specified requirements contained in the referenced standards or publications. The label or listing by the specified agency will be acceptable evidence of such compliance.

e. Before final acceptance of the cathodic protection system, submit one hard copy and one digital copy (.pdf - text searchable) of operating manuals outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features.

f. Submit one hard copy and one digital copy (.pdf - text searchable) of maintenance manuals, listing routine maintenance procedures, recommendation for maintenance testing, possible breakdowns and repairs, and troubleshooting guides. The manuals shall include single-line diagrams for the system as installed; instructions in making pipe-to-reference cell and tank-to-reference cell potential measurements and frequency of monitoring; instructions for dielectric connections, interference and sacrificial anode bonds; instructions shall include precautions to ensure safe conditions during repair of pipe or other metallic systems. The instructions shall be neatly bound between permanent covers and titled "Operating and Maintenance Instructions." These instructions shall be submitted for the Contracting Officer's approval. The instructions shall include the following:

1) As-built drawings, to scale, of the entire system, showing the locations of the piping, location of all anodes and test stations, locations of all insulating joints, and structure-to-soil potential test points as measured during the tests required by paragraph TESTS AND MEASUREMENTS. Each test point shall be given a unique alphanumeric identification that is cross referenced to the data sheets.

2) Recommendations for maintenance testing, including instructions in making pipe-to-reference cell potential measurements and frequency of testing.

3) All maintenance and operating instructions and nameplate data shall be in English.

4) Instructions shall include precautions to insure safe conditions during repair of pipe system.

1.2.1 Contractor's Modifications

The specified system is based on a complete system with magnesium sacrificial anodes. The Contractor may modify the cathodic protection system after review of the project, site verification, and analysis, if the proposed modifications include the anodes specified and will provide better overall system performance.

a. Submit one hard copy & one digital copy of detail drawings showing proposed changes in location, scope of performance indicating any variations from, additions to, or clarifications of contract drawings. Show proposed changes in anode arrangement, anode size and number, anode materials and layout details, conduit size, wire size, mounting details, wiring diagram, method for electrically-isolating each pipe, and any other pertinent information to proper installation and performance of the system. The modifications shall be fully described, shall be approved by the Contracting Officer, and shall meet the following criteria Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

b. The proposed system shall achieve a minimum pipe-to-soil "instant off" potential of minus 850 millivolts with reference to a saturated copper-copper sulfate reference cell on the underground components of the piping or other metallic surface. Take resistivity measurements of the soil in the vicinity of the pipes and ground bed sites. Based upon the measurements taken, the current and voltage shall be required to produce a minimum of minus 850 millivolts "instant off" potential between the structure being tested and the reference cell. This potential shall be obtained over 95 percent of the metallic area. The anode system shall be designed for a life of twenty-five (25) years of continuous operation.

c. Submit final report regarding Contractor's modifications. The report shall include pipe-to-soil measurements throughout the affected area, indicating that the modifications improved the overall conditions, and current measurements for anodes. The following special materials and information are required: taping materials and conductors; zinc grounding cell, installation and testing procedures, and equipment; coating material; system design calculations for anode number, life, and parameters to achieve protective potential; backfill shield material and installation details showing waterproofing; bonding and waterproofing details; insulated resistance wire; exothermic weld equipment and material.

1.2.2 Summary of Services Required

The scope of services shall include, but shall not be limited to, the following:

a. Close-interval potential surveys.

b. Cathodic Protection Systems.

c. System testing.

d. Casing corrosion control.

e. Interference testing.

f. Training.

g. Operating and maintenance manual.

h. Insulator testing and bonding testing.

i. Coating and holiday testing to be submitted within 45 days of notice to proceed.

1.2.3 Tests of Components

Perform a minimum of four (4) tests at each metallic component in the piping system. Two (2) measurements shall be made directly over the anodes and the other two (2) tests shall be over the outer edge of the component, but at the farthest point from the anodes. Structure and pipes shall be shown with the cathodic protection equipment. All components of the cathodic protection system shall be shown on drawings, showing their relationship to the protected structure or component. A narrative shall describe how the cathodic protection system will work and provide testing at each component. Components requiring cathodic protection shall include but not be limited to the following:

a. Pipes under the floor slab or foundations.

b. PIV.

c. Shutoff valves.

d. Metallic pipe extended from aboveground locations.

e. Each connector or change-of-direction device.

f. Any metallic pipe component or section.

g. Backflow preventer.

h. Culvert.

1.2.4 Electrical Potential Measurements

All potential tests shall be made at a minimum of 3 m (10 foot) intervals witnessed by the Contracting Officer. Submittals shall identify test locations on separate drawing, showing all metal to be protected and all cathodic protection equipment. Test points equipment and protected metal shall be easily distinguished and identified.

1.2.5 Achievement of Criteria for Protection

All conductors, unless otherwise shown, shall be routed to or through the test stations. Each system provided shall achieve a minimum pipe-to-soil "instant off" potential of minus 850 millivolt potentials with reference to a saturated copper-copper-sulfate reference cell on all underground components of the piping. Based upon the measurements taken, the current and voltage of the anodes should be adjusted as required to produce a minimum of minus 850 millivolts "instant off" potential between the structure being tested and the reference cell. This potential should be obtained over 95 percent of the metallic area. This must be achieved without the "instant off" potential exceeding 1150 millivolts. Testing will be witnessed by the Contracting Officer. Provide additional anodes if required to achieve the minus 850 millivolts "instant off". Although acceptance criteria of the cathodic protection systems are defined in NACE SP0169, for this project the "instant off" potential of minus 850 millivolts is the only acceptable criteria.

1.2.6 Metallic Components on Nonmetallic Systems and Typicals

a. Metallic components: As a minimum, protect each metallic component with two (2) magnesium anodes. This number of anodes is required to achieve minus 850 millivolts "instant off" potential on the metallic area and at the same time not provide overvoltage above 1150 millivolts "instant off." As a minimum, the magnesium anode unpackaged weight shall be 4.1 kg (9 pounds), unless otherwise indicated in contract drawings. The magnesium anodes shall be located on each side of the metallic component and routed through a test station.

b. Fire Hydrants: Fire hydrant pipe components shall have a minimum of two (2) anodes. These magnesium anodes shall have an unpackaged weight of 7.7 kg (17 pounds).

c. Pipe Under Concrete Slab: Pipe under concrete slab shall have a minimum of 2 magnesium anodes, unless otherwise indicated in contract drawings. These magnesium anodes shall have an unpackagedweight of

4.1 kg (9 pounds) unless otherwise indicated in contract drawings. Pipe under concrete slab shall have 2 permanent reference electrodes located under the slab. One (1) permanent reference electrode shall be located where the pipe enters the concrete slab. All conductors shall be routed to a test station.

d. Valves: Each valve shall be protected with 2 magnesium anodes, unless otherwise indicated in contract drawings. The magnesium anode shall have an unpackaged weight of 4.1 kg (9 pounds), unless otherwise indicated in contract drawings.

e. Metallic Pipe Component or Section: Each section of metallic pipe shall be protected with 3 magnesium anodes, unless otherwise indicated in contract drawings. The magnesium anodes shall have an unpackaged weight of 4.1 kg (9 pounds), unless otherwise indicated in contract drawings.

f. Connectors or Change-of-Direction Devices: Each change-of-direction device shall be protected with 2 magnesium anodes, unless otherwise indicated in contract drawings. The magnesium anode shall have an unpackaged weight of 4.1 kg (9 pounds), unless otherwise indicated in contract drawings.

1.2.7 Metallic Component Coating

Coatings for metallic components shall be as required for metallic fittings as indicated. This will include fire hydrants, T's, elbows, valves, etc. Coatings shall be selected, applied, and inspected as specified in these specifications. All aboveground pipeline shall be coated as indicated or as approved. The coating shall have a minimum thickness of 0.18 mm (7 mil). The pipeline coating shall be in accordance with all applicable ROK, provincial, and local regulations.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G
Contractor's Modifications; G

SD-03 Product Data

Equipment; G
Spare Parts

SD-06 Test Reports

Tests and Measurements
Contractor's Modifications

SD-07 Certificates

Cathodic Protection System

Services of "Corrosion Expert"; G

SD-10 Operation and Maintenance Data

Cathodic Protection System
Training Course

1.4 QUALITY ASSURANCE

1.4.1 Services of "Corrosion Expert"

Obtain the services of a "corrosion expert" to supervise, inspect, and test the installation and performance of the cathodic protection system. "Corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried or submerged metallic surfaces.

a. Such a person must be accredited or certified by the National Association of Corrosion Engineers (NACE) as a NACE Accredited Corrosion Specialist or a NACE certified Cathodic Protection (CP) Specialist or be a registered professional engineer who has certification or licensing that includes education and experience in corrosion control of buried or submerged metallic piping and tank systems, if such certification or licensing includes 5 years experience in corrosion control on underground metallic surfaces of the type under this contract.

b. The "corrosion expert" shall make at least 3 visits to the project site. The first of these visits shall include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the Contractor the type of cathodic protection required. Once the submittals are approved and the materials delivered, the "corrosion expert" shall revisit the site the ensure the Contractor understands installation practices and laying out the components. The third visit shall involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The "corrosion expert" shall supervise installation and testing of all cathodic protection.

c. Submit evidence of qualifications of the "corrosion expert" including its name and qualifications certified in writing to the Contracting Officer prior to the start of construction. Certification shall be submitted giving the name of the firm, the number of years of experience, and a list of not less than five (5) of the firm's installations, three (3) or more years old, that have been tested and found satisfactory.

1.4.2 Isolators

Isolators are required to insulate the indicated pipes from any other structure. Isolators shall be provided with lightning protection and a test station as shown.

1.4.3 Anode and Bond Wires

A minimum of 5 magnesium anodes with an unpackaged weight shall be provided uniform distances along the metallic pipe lines, unless otherwise indicated in contract drawings. A minimum of 5 test stations shall be used for these anodes, unless otherwise indicated in contract drawings. These anodes shall be in addition to anodes for the pipe under concrete slab and casing requirements. For each cathodic system, the metallic components and structures to be protected shall be made electrically continuous. This shall be accomplished by installing bond wires between the various structures. Bonding of existing buried structures may also be required to preclude detrimental stray current effects and safety hazards. Provisions shall be included to return stray current to its source without damaging structures intercepting the stray current. The electrical isolation of underground facilities in accordance with acceptable industry practice shall be included under this section. All tests shall be witnessed by the Contracting Officer.

1.4.4 Surge Protection

Approved zinc grounding cells or sealed weatherproof lightning arrestor devices shall be installed across insulated flanges or fittings installed in underground piping as indicated on the drawings. The arrestor shall be gapless, self-healing, solid state type. Zinc anode composition shall conform to ASTM B418, Type II. Lead wires shall be number 6 AWG copper with high molecular weight polyethylene (HMWPE) insulation. The zinc grounding cells shall not be prepackaged in backfill but shall be installed as detailed on the drawings. Lightning arrestors or zinc grounding cells are not required for insulated flanges on metallic components used on nonmetallic piping systems.

1.4.5 Nonmetallic Pipe System

In the event pipe other than metallic pipe is approved and used in lieu of metallic pipe, all metallic components of this pipe system shall be protected with cathodic protection. Detailed drawings of cathodic protection for each component shall be submitted to the Contracting Officer for approval within 45 days after date of receipt of notice to proceed, and before commencement of any work.

1.4.5.1 Coatings

Coatings for metallic components shall be as required for metallic fittings. Protective covering (coating and taping) shall be completed and tested on each metallic component (such as valves, hydrants and fillings). This covering shall be as required for underground metallic pipe. Each test shall be witnessed by the Contracting Officer. Coatings shall be selected, applied, and inspected as specified in these specifications. The use of nonmetallic pipe does not change other requirements of the specifications. Any deviations due to the use of nonmetallic pipe shall be submitted for approval.

1.4.5.2 Tracer Wire

When a nonmetallic pipe line is used to extend or add to an existing metallic line, an insulated No. 8 AWG copper wire shall be thermite-welded to the existing metallic line and run the length of the new nonmetallic line. This wire shall be used as a locator tracer wire and to maintain continuity to any future extensions of the pipe line.

1.4.6 Drawings

Submit one hard copy & one digital copy of detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, results of system design calculations including soil-resistivity, installation instructions and certified test data showing location of anodes and stating the maximum recommended anode current output density. Include in the detail drawings complete wiring and schematic diagrams, insulated fittings, test stations, permanent reference cells, and bonding and any other details required to demonstrate that the system has been coordinated and will function properly as a unit. Locations shall be referenced to two (2) permanent facilities or mark points. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

1.5 DELIVERY, STORAGE, AND HANDLING

Storage area for magnesium anodes will be provided by Contractor and approved by the Contracting Officer. If anodes are not stored in a building, tarps or similar protection should be used to protect anodes from inclement weather. Packaged anodes, damaged as a result of improper handling or being exposed to rain, shall not be used and disposed of by Contractor.

1.6 EXTRA MATERIALS

After approval of shop drawings, and not later than three (3) months prior to the date of beneficial occupancy, furnish spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than six (6) months prior to the date of beneficial occupancy. The data shall include a complete list of parts, special tools, and supplies, with current unit prices and source of supply. One (1) spare anode of each type shall be furnished. In addition, supply information for material and equipment replacement for all other components of the complete system, including anodes, cables, splice kits and connectors, corrosion test stations, and any other components not listed above. Furnish a reference cell on a reel with 120 m (350 feet) of conductor, along with other accessories, and a digital voltmeter that can be used in the maintenance of this cathodic protection system. Use of this equipment shall be demonstrated in actual tests during the training course, which shall include a description of the equipment and measurement of the pipe-to-soil potential, rainfall, and gas company voltages.

PART 2 PRODUCTS

2.1 MAGNESIUM ANODES

Install a minimum of 10 anodes on the Pipe or Tank system. See Paragraph METALLIC COMPONENTS ON NONMETALLIC SYSTEMS AND TYPICALS for additional anodes under slab.

2.1.1 Anode Composition

Anodes shall be of high-potential magnesium alloy, made of primary magnesium obtained from sea water or brine, and not made from scrap metal. Magnesium anodes shall conform to ASTM B843 and to the following analysis (in percents) otherwise indicated:

Aluminum, max.	0.010
Manganese, max.	0.50 to 1.30
Zinc	0.05

Silicon, max.	0.05
Copper, max.	0.02
Nickel, max.	0.001
Iron, Max.	0.03
Other impurities, max.	0.05 each or 0.3 max. total
Magnesium	Remainder

Furnish spectrographic analysis on samples from each heat or batch of anodes used on this project.

2.1.2 Dimensions and Weights

Dimensions and weights of anodes shall be approximately as follows:

TYPICAL MAGNESIUM ANODE SIZE

(Cross sections may be round, square, or D shaped)

NOMINAL WT. kg.	APPROX. SIZE (mm)	NOMINAL GROSS WT kg PACKAGED IN BACKFILL	NOMINAL PACKAGE DIMENSIONS (mm)
1.4	76 X 76 X 127	3.6	133 X 133 X 203
2.3	76 X 76 X 203	5.9	133 X 133 X 286
4.1	76 X 76 X 356	12.3	133 X 508
5.5	102 X 102 X 305	14.5	191 X 457
7.7	102 X 102 X 432	20.5	191 X 610
14.5	127 X 127 X 521	30.9	216 X 711
22.7	178 X 178 X 406	45.5	254 X 610

TYPICAL MAGNESIUM ANODE SIZE

(Cross sections may be round, square, or D shaped)

NOMINAL WT. LBS.	APPROX. SIZE (IN)	NOMINAL GROSS WT lb PACKAGED IN BACKFILL	NOMINAL PACKAGE DIMENSIONS (IN)
3	3 X 3 X 5	8	5-1/4 X 5-1/4 X 8
5	3 X 3 X 8	13	5-1/4 X 5-1/4 X 11-1/4
9	3 X 3 X 14	27	5-1/4 X 20
12	4 X 4 X 12	32	7-1/2 X 18
17	4 X 4 X 17	45	7-1/2 X 24
32	5 X 5 X 20-1/2	68	8-1/2 X 28
50	7 X 7 X 16	100	10 X 24

2.1.3 Packaged Anodes

Provide anodes in packaged form with the anode surrounded by specially-prepared quick-wetting backfill and contained in a water permeable cloth or paper sack. Anodes shall be centered by means of spacers in the backfill material. The backfill material shall have the following composition, unless otherwise indicated:

Material	Approximate Percent by Weight
Gypsum	75

Bentonite	20
Sodium Sulphate	5
Total	100

2.1.4 Zinc Anodes

Zinc anodes shall conform to ASTM B418, Type II.

2.1.5 Connecting Wire

2.1.5.1 Wire Requirements

Wire shall be No. 10 AWG solid copper wire, not less than 3 m (10 feet) long, unspliced, complying with NFPA 70, Type TW or RHW-USE insulation, unless otherwise indicated on contract drawings. Connecting wires for magnesium anodes shall be factory installed with the place or emergence from the anode in a cavity sealed flush with a dielectric sealing compound. Connecting wires for zinc anodes shall be factory installed with the place of connection to the protruding steel core completely sealed with a dielectric material.

2.1.5.2 Anode Header Cable

Cable for anode header and distribution shall be No. 8 AWG stranded copper wire with type CP high molecular weight polyethylene, 2.8 mm (7/64 inch) thick insulation, 600-volt rating, unless otherwise indicated on contract drawings.

2.2 MISCELLANEOUS MATERIALS

2.2.1 Electrical Wire

Wire shall be No. 10 AWG stranded copper wire with NFPA 70, Type TW, RHW-USE with outer covering, RHW-USE, or Polyethylene insulation, unless otherwise indicated on contract drawings. Polyethylene insulation shall comply with the requirements of ASTM D1248 and shall be of the following types, classes, and grades:

High-molecular weight polyethylene shall be Type I, Class C, Grade E5.

High-density polyethylene shall be Type III, Class C, Grade E3.

2.2.1.1 Wire Splicing

Connecting wire splicing shall be made with copper compression connectors or exothermic welds, following instructions of the manufacturer. Single split-bolt connections shall not be used. Sheaths for encapsulating electrical wire splices to be buried underground shall fit the insulated wires entering the spliced joints and epoxy potting compound shall be as specified below.

2.2.1.2 Test Wires

Test wires shall be AWG No. 12 stranded copper wire with NFPA 70, Type TW or RHW-USE with outer covering or polyethylene insulation.

2.2.1.3 Resistance Wire

Resistance wire shall be AWG No. 16 or No. 22 nickel-chromium wire.

2.2.2 Conduit

Rigid galvanized steel conduit and accessories shall conform to UL 6. Non metallic conduit shall conform to NEMA TC 2.

2.2.3 Test Boxes and Junctions Boxes

Boxes shall be outdoor type conforming to UL 514A.

2.2.4 Joint, Patch, Seal, and Repair Coating

Sealing and dielectric compound shall be a black, rubber based compound that is soft, permanently pliable, tacky, moldable, and unbacked. Compound shall be applied as recommended by the manufacturer, but not less than 13 mm (1/2-inch) thick. Coating compound shall be cold-applied coal-tar base mastic or hot-applied coal-tar enamel. Pressure-sensitive vinyl plastic electrical tape shall conform to UL 510.

2.2.5 Backfill Shields

Shields shall consist of approved pipeline wrapping or fiberglass-reinforced, coal-tar impregnated tape, or plastic weld caps, specifically made for the purpose and installed in accordance with the manufacturer's recommendations. When joint bonds are required, due to the use of mechanical joints, the entire joint shall be protected by the use of a kraft paper joint cover. The joint cover shall be filled with poured-in, hot coat-tar enamel.

2.2.6 Epoxy Potting Compound

Compound for encapsulating electrical wire splices to be buried underground shall be a two package system made for the purpose.

2.2.7 Test Stations

Stations shall be of the aboveground or flush-curb-box type as indicated on contract drawings/documents, and shall be the standard product of a recognized manufacturer. Test stations shall be complete with an insulated terminal block having the required number of terminals. The test station shall be provided with a lockable over and shall have an embossed legend, "C.P. Test." A minimum of one (1) test station shall be provided for each component of the pipe or tank. A minimum of six (6) terminals shall be provided in each test station. A minimum of two (2) leads are required to the metallic pipe from each test station. Other conductors shall be provided for each anode, other foreign pipe, and reference cells as required. Test stations may be constructed of nonmetallic materials. However, if nonmetallic materials are utilized, as a minimum, the materials shall be resistant to damage from ultraviolet radiation, contain good color retention qualities, contain high strength qualities, and be resistant to accidental or vandalistic impacts that might be normally encountered in the environment for which they are to be installed. The test stations shall be listed for the particular application for which they are to be utilized.

2.2.8 Joint and Continuity Bonds

Bonds shall be provided across all joints in the metallic water, gas, or other lines, across any electrically discontinuous connections and all other pipes and structures with other than welded or threaded joints that are included in this cathodic protection system. Unless otherwise specified in the specifications, bonds between structures and across joints in pipe with other than welded or threaded joints shall be No. 8 AWG stranded copper cable with polyethylene insulation. Bonds between structures shall contain sufficient slack for any anticipated movement between structures. Bonds across pipe joints shall contain a minimum of 102 mm (4 inch) of slack to allow for pipe movement and soil stress. Bonds shall be attached by exothermic welding. Exothermic weld areas shall be insulated with coating compound and approved, and witnessed by the Contracting Officer. Continuity bonds shall be installed as necessary to reduce stray current interference. Additional joint bonding shall be accomplished where the necessity is discovered during construction or testing or where the Contracting Officer's representative directs that such bonding be done. Joint bonding shall include all associated excavation and backfilling. There shall be a minimum of two (2) continuity bonds between each structure and other than welded or threaded joints. Test for electrical continuity across all joints with other than welded or threaded joints and across all metallic portions or components. Provide bonding as required and as specified above until electrical continuity is achieved. Submit bonding test data for approval.

2.2.9 Resistance Bonds

Resistance bonds should be adjusted as outlined in this specification. Alternate methods may be used if they are approved by the Contracting Officer.

2.2.10 Stray Current Measurements

Stray current measurements should be performed at each test station. Stray currents resulting from lightning or overhead alternating current (AC) power transmission systems shall be mitigated in accordance with NACE SP0177.

2.2.11 Electrical Isolation of Structures

As a minimum, isolating flanges or unions shall be provided at the following locations:

a. Connection of new metallic piping or components to existing piping.

b. Pressure piping under floor slab to a building.

Isolation shall be provided at metallic connection of all lines to existing system and where connecting to a building. Additionally, isolation shall be provided between water, fire protection, and/or gas, and/or forced main line; and foreign pipes that cross the new lines within 3.05 m (10 feet). Isolation fittings, including isolating flanges and couplings, shall be installed aboveground or in a concrete pit.

2.2.11.1 Electrically Isolating Pipe Joints

Electrically isolating pipe joints shall be of a type that is in regular factory production.

2.2.11.2 Electrically Conductive Couplings

Electrically conductive couplings shall be of a type that has a published maximum electrical resistance rating given in the manufacturer's literature. Cradles and seals shall be of a type that is in regular factory production made for the purpose of electrically insulating the carrier pipe from the casing and preventing the incursion of water into the annular space.

2.2.11.3 Insulating Joint Testing

A Model 601 Insulation Checker, as manufactured by "Gas Electronics" , or an approved equal, shall be used for insulating joint (flange) electrical testing.

2.2.12 Underground Structure Coating

This coating specification shall take precedence over any other project specification and drawing notes, whether stated or implied, and shall also apply to the pipeline or tank supplier. No variance in coating quality shall be allowed by the Contractor or Base Construction Representative without the written consent of the designer. All underground metallic pipelines and tanks to be cathodically protected shall be afforded a good quality factory-applied coating. This includes all carbon steel, cast-iron and ductile-iron pipelines or vessels. Coatings shall be selected, applied, and inspected as specified. If non-metallic pipelines are installed, all metallic fittings on pipe sections shall be coated in accordance with this specification section.

a. The nominal thickness of the metallic pipe joint or other component coating shall be 0.6 mm (24 mils), plus or minus 5 percent, unless otherwise indicated on contract drawings.

b. Pipe and joint coating for factory applied or field repair material shall be applied as recommended by the manufacturer and shall be one of the following:

    (1) Continuously extruded polyethylene and adhesive coating system.
    (2) Polyvinyl chloride pressure-sensitive adhesive tape.
    (3) High density polyethylene/bituminous rubber compound tape.
    (4) Butyl rubber tape.
    (5) Coal tar epoxy.

2.2.12.1 Field Joints

All field joints shall be coated with materials compatible with the pipeline coating compound. The joint coating material shall be applied to an equal thickness as the pipeline coating. Unbonded coatings shall not be used on these buried metallic components. This includes the elimination of all unbonded polymer wraps or tubes. Once the pipeline or vessel is set in the trench, an inspection of the coating shall be conducted. This inspection shall include electrical holiday detection. Any damaged areas of the coating shall be properly repaired. The Contracting Officer shall be asked to witness inspection of the coating and testing using a holiday detector.

2.2.12.2 Inspection of Pipe Coatings

Any damage to the protective covering during transit and handling shall be repaired before installation. After field coating and wrapping has been applied, the entire pipe shall be inspected by an electric holiday detector with impressed current in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. All holidays in the protective covering shall be repaired immediately upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer's representative to determine suitability of the detector. All labor, materials, and equipment necessary for conducting the inspection shall be furnished by the Contractor.

a. Protective covering for aboveground piping system: Finish painting shall conform to the applicable paragraph of SECTION: 09 90 00 PAINTS AND COATINGS and as follows:

b. Ferrous surfaces: Shop-primed surfaces shall be touched-up with ferrous metal primer. Surfaces that have not been shop-primed shall be solvent-cleaned. Surfaces that contain loose rust, loose mil scale, and other foreign substances shall be mechanically-cleaned by power wire-brushing and primed with ferrous metal primer. Primed surface shall be finished with two (2) coats of exterior oil paint and vinyl paint. Coating for each entire piping service shall be an approved pipe line wrapping having a minimum coating resistance of 50,000 Ohms per 0.0929 square meters square foot).

2.2.13 Resistance Wire

Wire shall be No. 16 or No. 22 nickel-chromium wire with TW insulation.

2.2.14 Electrical Connections

Electrical connections shall be done as follows:

a. Exothermic welds shall be "Cad-weld", " Bundy", "Thermoweld", or an approved equal. Use of this material shall be in strict accordance with the manufacturer's recommendations.

b. Electrical-shielded arc welds shall be approved for use on steel pipe by shop drawing submittal action.

c. Brazing shall be as specified in Paragraph: Lead Wire Connections.

2.2.15 Electrical Tape

Pressure-sensitive vinyl plastic electrical tape shall conform to UL 510.

2.2.16 Permanent Reference Electrodes

Permanent reference electrodes shall be Cu-CuS04 electrodes suitable for direct burial. Electrodes shall be guaranteed by the supplier for 15 years' service in the environment in which they shall be placed. Electrodes shall be installed directly beneath pipe, or metallic component.

2.2.17 Casing

Where a pipeline is installed in a casing under a roadway or railway, the pipeline shall be electrically insulated from the casing, and the annular space sealed and filled with an approved corrosion inhibiting product against incursion of water.

PART 3 EXECUTION

3.1 CRITERIA OF PROTECTION

Acceptance criteria for determining the adequacy of protection on a buried underground pipe, tank, or metallic component shall be in accordance with NACE SP0169, NACE RP0193, or NACE SP0285, as applicable and as specified below.

3.1.1 Iron and Steel

The following method a. shall be used for testing cathodic protection voltages. If more than one method is required, method b. shall be used.

a. A negative voltage of at least minus 850 millivolts as measured between the underground component and a saturated copper-copper sulphate reference electrode connecting the earth (electrolyte) directly over the underground component. Determination of this voltage shall be made with the cathodic protection system in operation. Voltage drops shall be considered for valid interpretation of this voltage measurement. A minimum of minus 850 millivolts "instant off" potential between the underground component being tested and the reference cell shall be achieved over 95 percent of the area of the structure. Adequate number of measurements shall be obtained over the entire structure, pipe, tank, or other metallic component to verify and record achievement of minus 850 millivolts "instant off." This potential shall be obtained over 95 percent of the total metallic area without the "instant off" potential exceeding 1200 millivolts.

b. A minimum polarization voltage shift of 100 millivolts as measured between the underground component and a saturated copper-copper sulphate reference electrode contacting the earth directly over the underground component. This polarization voltage shift shall be determined by interrupting the protective current and measuring the polarization decay. When the protective current is interrupted, an immediate voltage shift will occur. The voltage reading, after the immediate shift, shall be used as the base reading from which to measure polarization decay. Measurements achieving 100 millivolts decay shall be made over 95 percent of the metallic surface being protected.

c. For any metallic component, a minimum of four (4) measurements shall be made using subparagraph a., above, and achieving the "instant off" potential of minus 850 millivolts. Two (2) measurements shall be made over the anodes and two (2) measurements shall be made at different locations near the component and farthest away from the anode.

3.1.2 Aluminum

Aluminum underground component shall not be protected to a potential more negative than minus 1200 millivolts, measured between the underground component and a saturated copper-copper sulphate reference electrode contacting the earth, directly over the metallic component. Resistance, if required, shall be inserted in the anode circuit within the test station to reduce the potential of the aluminum to a value which will not exceed a potential more negative than minus 1200 millivolts. Voltage shift criterion shall be a minimum negative polarization shift of 100 millivolts measured between the metallic component and a saturated copper-copper sulphate reference electrode contacting the earth, directly over the metallic component. The polarization voltage shift shall be determined as outlined for iron and steel.

3.1.3 Copper Piping

For copper piping, the following criteria shall apply: A minimum of 100 millivolts of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The polarization voltage shift shall be determined as outlined for iron and steel.

3.2 TRENCHING AND BACKFILLING

Perform trenching and backfilling in accordance with Section 31 00 00 EARTHWORK . In the areas of the anode beds, all trees and underbrush shall be cleared and grubbed to the limits shown or indicated. In the event rock is encountered in providing the required depth for anodes, determine an alternate approved location and, if the depth is still not provided, submit an alternate plan to the Contracting Officer. Alternate techniques and depths must be approved prior to implementation.

3.3 INSTALLATION

3.3.1 Anode Installation

Unless otherwise authorized, installation shall not proceed without the presence of the Contracting Officer. Anodes of the size specified shall be installed to the depth indicated and at the locations shown. Locations may be changed to clear obstructions with the approval of the Contracting Officer. Anodes shall be installed in sufficient number and of the required type, size, and spacing to obtain a uniform current distribution over the surface of the structure. The anode system shall e designed for a life of 25 years of continuous operation. Anodes shall be installed as indicated in a dry condition after any plastic or waterproof protective covering has been completely removed from the water permeable, permanent container housing the anode metal. The anode connecting wire shall not be used for lowering the anode into the hole. The annular space around the anode shall be backfilled with fine earth in 150 mm (6 inch) layers and each layer shall be hand tamped. Care must be exercised not to strike the anode or connecting wire with the tamper. Approximately 20 L (5 gallons) of water shall be applied to each filled hole after anode backfilling and tamping has been completed to a point about 150 mm (6 inch) above the anode. After the water has been absorbed by the earth, backfilling shall be completed to the ground surface level.

3.3.1.1 Single Anodes

Single anodes, spaced as shown, shall be connected through a test station to the pipeline, allowing adequate slack in the connecting wire to compensate for movement during backfill operation.

3.3.1.2 Groups of Anodes

Groups of anodes, in quantity and location shown, shall be connected to an anode header cable. The anode header cable shall make contact with the structure to be protected only through a test station. Anode lead connection to the anode header cable shall be made by an approved crimp connector or exothermic weld and splice mold kit with appropriate potting compound.

3.3.1.3 Welding Methods

Connections to ferrous pipe or metal tanks shall be made by exothermic weld methods manufactured for the type of pipe or tank supplied. Electric arc welded connections and other types of welded connections to ferrous pipe and structures shall be approved before use.

3.3.2 Anode Placement - General

Packaged anodes shall be installed completely dry, and shall be lowered into holes by rope sling or by grasping the cloth gather. The anode lead wire shall not be used in lowering the anodes. The hole shall be backfilled with fine soil in 150 mm (6 inch) layers and each layer shall be hand-tamped around the anode. Care must be exercised not to strike the anode or lead wire with the tamper. If immediate testing is to be performed, water shall be added only after backfilling and tamping has been completed to a point 150 mm (6 inch) above the anode. Approximately 8 L (2 gallons) of water may be poured into the hole. After the water has been absorbed by the soil, backfilling and tamping may be completed to the top of the hole. Anodes shall be installed as specified or shown. In the event a rock strata is encountered prior to achieving specified augered-hole depth, anodes may be installed horizontally to a depth at least as deep as the bottom of the pipe, with the approval of the Contracting Officer.

3.3.3 Underground Pipeline

Anodes shall be installed at a minimum of 2.5 m (8 feet) and a maximum of 3 m (10 feet) from the line to be protected.

3.3.4 Installation Details

Details shall conform to the requirements of this specification. Details shown on the drawings are indicative of the general type of material required, and are not intended to restrict selection to material of any particular manufacturer.

3.3.5 Lead Wire Connections

3.3.5.1 Underground Pipeline (Metallic)

To facilitate periodic electrical measurements during the life of the sacrificial anode system and to reduce the output current of the anodes, if required, all anode lead wires shall be connected to a test station and buried a minimum of 610 mm (24 inch) in depth. The cable shall be No. 10 AWG, stranded copper, polyethylene or RHW-USE insulated cable. The cable shall make contact with the structure only through a test station. Resistance wire shall be installed between the cable and the pipe cable, in the test station, to reduce the current output, if required. Anode connections, except in the test station, shall be made with exothermic welding process, and shall be insulated by means of at least three (3) layers of electrical tape; and all lead wire connections shall be installed in a moisture proof splice mold kit and filled with epoxy resin. Lead wire-to-structure connections shall be accomplished by an exothermic welding process. All welds shall be in accordance with the manufacturer's recommendations. A backfill shield filled with a pipeline mastic sealant or material compatible with the coating shall be placed over the weld connection and shall be of such diameter as to cover the exposed metal adequately.

3.3.5.2 Resistance Wire Splices

Resistance wire connections shall be accomplished with silver solder and the solder joints wrapped with a minimum of three (3) layers of pressure-sensitive tape. Lead wire connections shall be installed in a moisture proof splice mold kit and filled with epoxy resin.

3.3.6 Location of Test Stations

Test stations shall be of the type and location shown and shall be curb box, post, or indoor mounted. Provide buried insulating joints with test wire connections brought to a test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations as follows:

a. At 300 m (1,000-foot) intervals or less.

b. Where the pipe or conduit crosses any other metal pipe.

c. At both ends of casings under roadways and railways.

d. Where both sides of an insulating joint are not accessible above ground for testing purposes.

3.3.7 Underground Pipe Joint Bonds

Underground pipe having other than welded or threaded coupling joints shall be made electrically continuous by means of a bonding connection installed across the joint.

3.4 ELECTRICAL ISOLATION OF STRUCTURES

3.4.1 Isolation Joints and Fittings

Isolating fittings, including main line isolating flanges and couplings, shall be installed aboveground, or within manholes, wherever possible. Where isolating joints must be covered with soil, they shall be fitted with a paper joint cover specifically manufactured for covering the particular joint, and the space within the cover filled with hot coal-tar enamel. Isolating fittings in lines entering buildings shall be located at least 305 mm (12 inch) above grade of floor level, when possible. Isolating joints shall be provided with grounding cells to protect against over-voltage surges or approved surge protection devices. The cells shall provide a low resistance across isolating joint without excessive loss of cathodic current.

3.4.2 Gas Distribution Piping

Electrical isolation shall be provided at each building riser pipe to the pressure regulator, at all points where a short to another structure or to a foreign structure may occur, and at other locations as indicated on the drawings.

3.5 TESTS AND MEASUREMENTS

Submit test reports in booklet form tabulating all field tests and measurements performed, upon completion and testing of the installed system and including close interval potential survey, casing and interference tests, final system test verifying protection, insulated joint and bond tests, and holiday coating test. Submit a certified test report showing that the connecting method has passed a 120-day laboratory test without failure at the place of connection, wherein the anode is subjected to maximum recommended current output while immersed in a three percent sodium chloride solution. For Air Force projects, Contractor shall prepare and submit one hard copy and one digital copy of Air Force Form 1686 for the Air Force facility. Instructions for completing this form are in UFC 3-570-06 APPENDIX A PART 3. If the cathodic protection test is completed before the entire project is finished, contractor shall complete and submit the form monthly until the contract is completed.

3.5.1 Baseline Potentials

Each test and measurement will be witnessed by the Contracting Officer. Notify the Contracting Officer a minimum of five (5) working days prior to each test. After backfill of the pipe and/or tank, the static potential-to-soil of the pipe and/or tank shall be measured. The locations of these measurements shall be identical to the locations specified for pipe- to-reference or tank-to-reference electrode potential measurements. The initial measurements shall be recorded.

3.5.2 Isolation Testing

Before the anode system is connected to the pipe and/or tank, an isolation test shall be made at each isolating joint or fitting. This test shall demonstrate that no metallic contact, or short circuit exists between the two isolated sections of the pipe and/or tank. Any isolating fittings installed and found to be defective shall be reported to the Contracting Officer.

3.5.2.1 Insulation Checker

A Model 601 insulation checker, as manufactured by "Gas Electronics" or an approved equal, using the continuity check circuit, shall be used for isolating joint (flange) electrical testing. Testing shall conform to the manufacturer's operating instructions. Test shall be witnessed by the Contracting Officer. An isolating joint that is good will read full scale on the meter. If an isolating joint is shorted, the meter pointer will be deflected or near zero on the meter scale. Location of the fault shall be determined from the instructions, and the joint shall be repaired. If an isolating joint is located inside a vault, the pipe shall be sleeved with insulator when entering and leaving the vault.

3.5.2.2 Cathodic Protection Meter

A Model B3A2 cathodic protection meter, as manufactured by "M.C. Miller" or an approved equal, using the continuity check circuit, shall be used for isolating joint (flange) electrical testing. This test shall be performed in addition to the Model 601 insulation checker. Continuity is checked across the isolation joint after the test lead wire is shorted together and the meter adjusted to scale. A full-scale deflection indicates the system is shorted at some location. The Model 601 verifies that the particular insulation under test is good and the Model B3A2 verifies that the system is isolated. If the system is shorted, further testing shall be performed to isolate the location of the short.

3.5.3 Anode Output

As the anodes or groups of anodes are connected to the pipe or tank, current output shall be measured with an approved clamp-on milliammeter, calibrated shunt with a suitable millivoltmeter or multimeter, or a low resistance ammeter. (Of the three methods, the low-resistance ammeter is the least desirable and most inaccurate. The clamp-on milliammeter is the most accurate.) The values obtained and the date, time, and location shall be recorded.

3.5.4 Reference Electrode Potential Measurements

Upon completion of the installation and with the entire cathodic protection system in operation, electrode potential measurements shall be made using a copper-copper sulphate reference electrode and a potentiometer-voltmeter, or a direct-current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements shall be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements shall be recorded. No less than eight (8) measurements shall be made over any length of line or component. Additional measurements shall be made at each distribution service riser, with the reference electrode placed directly over the service line.

3.5.5 Location of Measurements

3.5.5.1 Piping or Conduit

For coated piping or conduit, measurements shall be taken from the reference electrode located in contact with the earth, directly over the pipe. Connection to the pipe shall be made at service risers, valves, test leads, or by other means suitable for test purposes. Pipe-to-soil potential measurements shall be made at intervals not exceeding 3 m (10 feet). The Contractor may use a continuous pipe-to-soil potential profile in lieu of 1.5 m (5 foot) interval pipe-to-soil potential measurements. Additional measurements shall be made at each distribution service riser, with the reference electrode placed directly over the service line adjacent to the riser. Potentials shall be plotted versus distance to an approved scale. Locations where potentials do not meet or exceed the criteria shall be identified and reported to the Contracting Officer's representative.

3.5.5.2 Tanks

For underground tanks, at least 6 measurements shall be taken from the reference electrode located:

a. Directly over the center of the tank.

b. At a point directly over the tank and midway between each pair of anodes.

3.5.5.3 Casing Tests

Before final acceptance of the installation, the electrical separation of carrier pipe from casings shall be tested and any short circuits corrected.

3.5.5.4 Interference Testing

Before final acceptance of the installation, interference tests shall be made with respect to any foreign pipes or tanks in cooperation with the owner of the foreign pipes or tanks. A full report of the tests giving all details shall be made. Stray current measurements shall be performed at all isolating locations and at locations where the new pipeline crosses foreign metallic pipes; results of stray current measurements shall also be submitted for approval. The method of measurements and locations of measurements shall be submitted for approval. As a minimum, stray current measurements shall be performed at the following locations:

a. Connection point of new pipeline to existing pipeline.

b. Crossing points of new pipeline with existing lines.

3.5.5.5 Holiday Test

Any damage to the protective covering during transit and handling shall be repaired before installation. After field-coating and wrapping has been applied, the entire pipe shall be inspected by an electric holiday detector with impressed current in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective covering shall be repaired upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer to determine suitability of the detector. Labor, materials, and equipment necessary for conducting the inspection shall be furnished by the Contractor. The coating system shall be inspected for holes, voids, cracks, and other damage during installation.

3.5.5.6 Recording Measurements

All pipe-to-soil and tank- to-soil potential measurements, including initial potentials where required, shall be recorded. Locate, correct and report to the Contracting Officer any short circuits to foreign pipes or tanks encountered during checkout of the installed cathodic protection system. Pipe-to-soil and Tank-to-soil potential measurements shall be taken on as many pipes or tanks as necessary to determine the extent of protection or to locate short-circuits.

3.6 TRAINING COURSE

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. Submit the proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions. At least 14 days prior to date of proposed conduction of the training course, the training course curriculum shall be submitted for approval, along with the proposed training date. Training shall consist of demonstration of test equipment, providing forms for test data and the tolerances which indicate that the system works.

3.7 SYSTEM TESTING

Submit a report including potential measurements taken at adequately-close intervals to establish that minus 850 millivolts potential, "instant-off" potential, is provided, and that the cathodic protection is not providing interference to other foreign pipes causing damage to paint or pipes. The report shall provide a narrative describing how the criteria of protection are achieved without damaging other pipe or structures in the area.

3.8 SEEDING

Seeding shall be done as directed, in all unsurfaced locations disturbed by this construction. In areas where grass cover exists, it is possible that sod can be carefully removed, watered, and stored during construction operations, and replaced after the operations are completed since it is estimated that no section of pipeline should remain uncovered for more than two (2) days. The use of sod in lieu of seeding shall require approval by the Contracting Officer.

3.9 CLEANUP

The Contractor is responsible for cleanup of the construction site. All paper bags, wire clippings, etc., shall be disposed of as directed. Paper bags, wire clippings and other waste shall not be put in bell holes or anodes excavation.

-- End of Section --

SECTION 26 42 17.00 10

CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT)
11/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B418	(2012) Standard Specification for Cast and Wrought Galvanic Zinc Anodes
ASTM B843	(2013) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

NACE INTERNATIONAL (NACE)

NACE RP0193	(2001) External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms
NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP0572	(2001; R 2007) Design, Installation, Operation and Maintenance of Impressed Current Deep Anode Beds

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 506	(2008; Reprint Oct 2013) Specialty Transformers
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel

1.2 SYSTEM DESCRIPTION

Submit proof that the materials and equipment furnished under this section conform to the specified requirements contained in the referenced standards or publications. The label or listing by the specified agency will be acceptable evidence of such compliance.

1.2.1 General Requirements

a. Provide a complete, operating impressed current cathodic protection system in accordance with NFPA 70, the applicable federal, state and local regulations, and the requirements of this contract. In addition to the minimum requirements of these specifications, construction of gas pipelines and associated cathodic protection systems shall be in compliance with 49 CFR 192, construction of hazardous liquid pipelines and associated cathodic protection system shall be in compliance with 49 CFR 195, and construction and installation of underground fuel storage tanks and associated cathodic protection system shall be in compliance with 40 CFR 280.

b. The system includes planning, inspecting the installation, adjusting and testing cathodic protection and test system using rectifiers and impressed current anodes, supplemented with sacrificial anodes as needed, for utilities and equipment shown. The cathodic protection system shall also include cables, connectors, splices, corrosion protection test stations, ace power panels, and any other equipment required for a complete operating system providing the specified protection. The cathodic protection system includes (a) calculations for rectifier, anodes, and any recommendations for supplementing or changing the minimum design criteria to provide the specified potentials and (b) equipment, wiring, and wiring devices necessary to produce a continuous flow of direct current from anodes in the soil electrolyte to the pipe surfaces.

c. Submit one hard copy & one digital copy of Detail Drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, results of system design calculations including soil resistivity, installation instructions and certified test data stating the maximum recommended anode current output density and the rate of gaseous production, if any, at that current density. Detail drawings shall contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function properly as a unit. The installation shall meet the specified protection criteria for a 25 year life. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

d. Submit one hard copy and one digital copy (.pdf - text searchable) of operating manual outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features.

e Submit one hard copy and one digital copy (.pdf - text searchable) of maintenance manual listing routine maintenance procedures, recommendation for maintenance testing, possible breakdowns and repairs, and troubleshooting guides. The manuals shall include single line diagrams for the system as installed; instructions for making pipe-to-reference and tank-to-reference cell potential measurements and frequency of monitoring; instructions for dielectric connections, interference and sacrificial anode bonds; instructions shall include precautions to ensure safe conditions during repair of pipe system.

1.2.2 Contractor's Modifications

The specified system is based on an impressed current system supplemented with magnesium anodes. The Contractor may modify the cathodic protection system after review of the project, site verification and analysis if the proposed modifications include the impressed current anodes and rectifiers and will provide better overall system performance.

a. Submit one hard copy & one digital copy of detail drawings showing proposed changes in location, scope or performance indicating any variations from, additions to, or clarifications of contract drawings. The drawings shall show proposed changes in anode arrangement, anode size and number, anode materials and layout details, conduit size, wire size, mounting details, wiring diagram, method for electrically isolating each pipe, and any other pertinent information to the proper installation and performance of the system. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

b. The modifications shall be fully described, shall be approved by the Contracting Officer, and shall meet the following criteria: the proposed system shall achieve a minimum pipe-to-soil "Instant Off" potential of minus 850 millivolts with reference to a saturated copper-copper sulfate reference cell on the underground metallic components of the piping and/or tanks.

c. Take resistivity measurements of the soil in the vicinity of the pipes or tanks and ground bed sites; based upon the measurements taken, adjust current and voltage of the rectifier as required to produce a minimum of minus 850 millivolts "Instant Off" potential between the structure being tested and the reference cell. This potential shall be obtained over 95 percent of the metallic area without the "Instant Off" potential exceeding 1200 millivolts.

d. Submit final report regarding supplemental magnesium anode installation. The report shall include pipe-to-soil measurements throughout the affected area, indicating that the additions corrected the conditions which made the additional anodes necessary, and current measurements for the additional anodes. The following special materials and information are required: Calculations on current and voltage for 100 V or 40 V rectifier plus rectifier and meter specifications; taping materials and conductors; zinc grounding cell, installation and testing procedures, and equipment; coating material; system design calculations for rectifier, anode number, life, and parameters to achieve protective potential; backfill shield material and installation details showing waterproofing; bonding and waterproofing details; insulated resistance wire; exothermic weld equipment and material.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G
Contractor's Modifications; G

SD-03 Product Data

Miscellaneous Materials
Spare Parts

SD-06 Test Reports

Tests and Measurements
Contractor's Modifications

SD-07 Certificates

Tests and Measurements
Cathodic Protection System
Services of "Corrosion Expert"; G

SD-10 Operation and Maintenance Data

Cathodic Protection System
Training Course

1.4 QUALITY ASSURANCE

1.4.1 Services of "Corrosion Expert"

Obtain the services of a "corrosion expert" to supervise, inspect, and test the installation and performance of the cathodic protection system. "Corrosion expert" refers to a person, who, by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried metallic piping and tank systems.

a. Such a person shall be accredited or certified by the National Association of Corrosion Engineers (NACE) as a NACE Accredited Corrosion Specialist or a NACE certified Cathodic Protection (CP) Specialist or be a registered professional engineer who has certification or licensing that includes education and experience in corrosion control of buried or submerged metallic piping and tank systems, if such certification or licensing includes 5 years experience in corrosion control on underground metallic surfaces of the type under this contract.

b. Submit the "corrosion expert's" name and qualifications certified in writing to the Contracting Officer prior to the start of construction, including the name of the firm, the number of years of experience, and a list of not less than five of the firm's installations three or more years old that have been tested and found satisfactory.

c. The "corrosion expert" shall make at least 3 visits to the project site. The first of these visits shall include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the Contractor the type of cathodic protection required. Once the submittals are approved and the materials delivered, the "corrosion expert" shall revisit the site to ensure the Contractor understands installation practices and laying out the components. The third visit shall involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The "corrosion expert" shall supervise installation and testing of all cathodic protection.

1.4.2 Isolators

Isolators are required to isolate the indicated pipes from any other structure. Isolators shall be provided with lightning protection and a test station as shown.

1.4.3 Anodes and Bond Wires

Install anodes in sufficient number and of the required type, size and spacing to obtain a uniform current distribution of 2.5 milliamperes per 0.09 square meters (square foot) minimum to underground metal surfaces. For each cathodic protection system, the metallic components and structures to be protected shall be made electrically continuous. This shall be accomplished by installing bond wires between the various structures. Bonding of existing buried structures may also be required to preclude detrimental stray current effects and safety hazards. Provisions shall be included to return stray current to its source without damaging structures intercepting the stray current. The electrical isolation of underground facilities in accordance with acceptable industry practice shall be included under this section.

1.4.4 Surge Protection

Install approved zinc grounding cells or sealed weatherproof lightning arrestor devices across insulated flanges or fittings installed in underground piping as indicated on the drawings. The arrestor shall be gapless, self-healing, solid state type. Zinc anode composition shall conform to ASTM B418, Type II. Lead wires shall be number 6 AWG copper with high molecular weight polyethylene (HMWPE) insulation. The zinc grounding cells shall not be prepackaged in backfill but shall be installed as detailed on the drawings. Lightning arrestors or zinc grounding cells are not required for insulated flanges on metallic components used on nonmetallic piping systems.

1.4.5 Sacrificial Anodes

Locate sacrificial high potential magnesium anodes as required to provide localized cathodic protection or supplemental cathodic protection for the impressed current system. Each sacrificial magnesium anode shall be routed through a test station. The magnesium anode shall not be connected to the pipe.

1.4.6 Nonmetallic Pipe Systems

When nonmetallic pipe is approved, direct buried or submerged metallic components of the pipe system shall have cathodic protection. Metallic components are connectors, tees, fire hydrants, valves, short pipes, elbows, tie rods, or other metallic equipment. As a minimum, each metallic component shall be protected with a 4.1 kg (9 lb) magnesium anode connected through a test station. The use of nonmetallic pipe does not change other requirements of the specifications such as submittals, testing, or design calculations for each metallic component. Deviations due to the use of nonmetallic pipe shall be approved by the Contracting Officer.

1.4.6.1 Coatings

Coatings for metallic components shall be as required for metallic fittings. Protective covering (coating and taping) shall be completed and tested on each metallic component and shall be as required for underground metallic pipe. Mechanical joints and fittings of either the electrically conductive or insulating type shall be coated with an underground type dielectric coating system. Where external electrical continuity bonds are installed across mechanical joints, bare or exposed metal, welds, bare wire and exposed coupling parts shall be coated with a coating system.

a. Couplings and fittings which have a low profile exterior designed to permit tape coating shall be primed and wrapped with an underground type pipe tape system or two-part epoxy system.

b. Couplings and fittings that cannot be properly taped shall be enclosed in a spaced mold manufactured for the purpose and filled with cold applied dielectric compound or hot applied bituminous compound not exceeding 135 degrees C 275 degrees F in application temperature.

1.4.6.2 Tracer Wire

When a nonmetallic pipe line is used to extend or add to an existing metallic line, an insulated No. 8 AWG copper wire shall be connected to a terminal in a test station located at each point of transition from metallic pipe to nonmetallic pipe. At each of these test stations, the tracer wire terminal shall be strapped or bonded to the terminal for the negative connection wire to the existing metallic line. The tracer wire shall be run the length of the new nonmetallic line. This wire shall be used as a locator tracer wire and to maintain continuity to any future extension of the pipe line.

1.5 DELIVERY, STORAGE, AND HANDLING

Storage for magnesium anodes will be provided by Contractor and approved by the Contracting Officer. If anodes are not stored in a building, protect them from inclement weather. Packaged anodes damaged as result of improper handling or weather exposure shall not be used and disposed of by Contractor

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than 2 months prior to the date of beneficial occupancy. Include in the data a complete list of parts, special tools, and supplies, with current unit prices and source of supply. Furnish one spare anode of each type.

PART 2 PRODUCTS

2.1 IMPRESSED CURRENT ANODES

2.1.1 Bare High Silicon Cast-Iron Anodes

Cast-iron anodes shall be of the size indicated and shall conform to the following requirements:

2.1.1.1 Chemical Composition (Nominal)

Element	Percent by Weight Grade 2
Silicon	14.20-14.75
Manganese	1.50 Max.
Carbon	0.75-1.15
Chromium	3.25-5.00
Iron	Balance

2.1.1.2 Electrical Resistivity

Seventy-two microhm-centimeter at minus 7 degrees C (20 degrees F).

2.1.1.3 Physical Properties (Nominal)

Tensile strength	103.4 MPa
Compressive strength	689.5 MPa
Brinell hardness	520
Density	7000 kilograms per cubic meter
Melting point	1260 degrees C

Coefficient of expansion from 0 to 100 degree C	132 nanometer per degree C
Tensile strength	15,000 psi
Compressive strength	100,000 psi
Brinell hardness	520
Density	7.0 grams per cubic centimeter
Melting point	2300 degrees F
Coefficient of expansion from 32 to 212 degrees F	0.00000733 centimeter per degree F

2.1.2 Bare Graphite Anodes

Bare graphite anodes shall have a maximum electrical resistivity of 0.0011 ohm-centimeter.

2.1.3 Canister Contained Anodes

Canister contained anodes shall be packed at the factory in sheet metal canisters with calcined petroleum coke breeze. The coke shall have a resistivity of 0.1 ohm-cm tested at 1034 kPa (150 psi). The coke shall be 11244 kg/cubic meter (70 lbs/cubic foot) or greater. The maximum particle size shall be 1 mm (0.039 inch) and the coke shall be dust-free. The canisters shall be capped with tight fitting end caps secured to the body of the canister. The canister shall provide a minimum annular space of 75 mm (3 inch) all around the anode. The connecting cable shall pass through a hole in an end cap designed to be tight fitting with the cable and protected from sharp edges with a plastic or rubber grommet. The anodes shall be centered in the canisters and the annular space filled with coke breeze compacted in place.

2.1.4 Anode Connecting Cables

Anodes shall have connecting cables installed at the factory. For deep ground beds, each anode located in the borehole shall be accompanied by a reel of continuous cable having the length indicated. No spliced connections will be permitted in deep well cables.

2.1.5 Mixed Metal Oxide Anodes

Mixed metal oxide anodes shall be of the size indicated and shall conform to the following requirements.

2.1.5.1 Conductive Material

The electrically conductive coating shall contain a mixture consisting primarily of iridium, tantalum, and titanium oxides. The average composition is generally a 50/50 atomic percent mixture of iridium and titanium oxides, with a small amount of tantalum. The resistivity, as tested by the manufacturer, shall be no more than 0.002 ohm-centimeter, and the bond strength shall be greater than 50 MPa (7.25 ksi) to guarantee the current capacity life and the quality of the conductive ceramic coating. The adhesion or bond strength shall be determined by epoxy bonding a 2.54 mm (0.1 inch) diameter stud to the ceramic coating and measuring the load to failure (about 70 MPa (10.15 ksi)) of either the epoxy or the interface between the coating and the substrate. The anode must be inert and the electrically conductive ceramic coating dimensionally stable. The ceramic coated anode shall be capable of sustaining a current density of 100 ampere per square meter (10.764 square feet) in an oxygen generating electrolyte at 66 degrees C (150 degrees F) for 20 years, to ensure the current capacity life. An accelerated current capacity life test shall be performed by the manufacturer on every lot of anode wire used to construct the anode as described. The mixed metal oxide coating shall be applied to the wire anode by a firm that is regularly engaged in and has a minimum 5 years experience in manufacturing and applying mixed metal oxide coatings to titanium anode substrates. The mixed metal oxide must be sintered to the titanium surface as to remain tightly bound to the surface when bent 180 degrees onto itself.

2.1.5.2 Anode Life Test

The anode wire material shall sustain current densities of 100 ampere per square meter (10.764 square feet) in an oxygen generating electrolyte for 20 years. The manufacturer shall certify that a representative sample taken from the same lot used to construct the anode, has been tested and meets the following criteria. The test cell sustains a current density of 10,000 ampere per square meter (10.764 square feet) in a 15 weight percent sulfuric acid electrolyte at 66 degrees C (150 degrees F) without an increase in anode to cathode potential of more than 1 volt. The cell containing the anode shall be powered with a constant current power supply for the 30 day test period. The representative sample shall be 125 mm (5 inch) in length taken from the lot of wire that is to be used for the anode.

2.1.5.3 Canister Contained Mixed Metal Oxide Anodes

Canister contained mixed metal oxide anodes shall be packed at the factory in light weight, light gauge steel uni-body TIG welded canisters with calcinated petroleum coke breeze. The canisters shall be capped with TIG welded steel and caps providing a totally encapsulated construction. The connecting cable shall pass through a hole in an end cap designed to be tight fitting with a heavy duty strain relief allowing for handling of the canister by the cable. The anode shall be centered in the canister by centralizers to maintain rod position.

2.1.5.4 Anode Connecting Cables

Anodes shall have connecting cables installed at the factory. The connection between the anode rod or ribbon and the lead wire shall be made with a solid crimp couple with solder. The connection shall be sealed in cast epoxy.

2.1.5.5 Canister Connection Cables

Canister connecting cables shall consist of an ultra low resistance solder connection which is a minimum of three times stronger than the cable. For ceramic coated canister anodes, the cable connection shall consist of two molded dielectric layers (pressure seals), a flexible backfill resin encapsulant stabilizer, a schedule 40 PVC pipe Type 1 seal, and Type 1 PVC pipe end plugs. The seals and end plugs shall resist chlorine gas and acid.

2.1.5.6 Deep Anode Connection Cables

For deep anode beds, each anode located in the borehole shall be accompanied by a reel of continuous cable having the length indicated. For deep ceramic coated anode beds, anode connecting cables shall have molded multiseal solder connections; splices will not be permitted. Chlorine gas resistant cable and shield shall be used for chlorine environments.

2.2 RECTIFIERS AND ASSOCIATED EQUIPMENT

2.2.1 Rectifier Unit

Rectifier unit shall consist of a transformer, rectifying elements, transformer tap adjuster, terminal block, one dc output voltmeter, one dc output ammeter, one toggle switch for each meter, fuse holders with fuses for each dc circuit, variable resistors, an ac power-supply circuit breaker, lightning arresters for both input and output, all wired and assembled in a weatherproof cabinet. The overall efficiency of the rectifier shall be not less than 65 percent when operated at nameplate rating and shall be capable of supplying continuous full rated output at an ambient temperature of 44 degrees C (112 degrees F) in full sunlight with expected life in excess of 10 years.

2.2.1.1 Transformer

Transformer shall conform to UL 506.

2.2.1.2 Rectifiers

Rectifying elements shall be silicon diodes connected to provide full-wave rectification. Silicon diodes shall be protected by selenium surge cells or varistors against over-voltage surges and by current-limiting devices against over-current surges.

2.2.1.3 Meters

Meters shall be accurate to within plus or minus 2 percent of full scale at 27 degrees C (80 degrees F), and shall possess temperature stability above and below 27 degrees C (80 degrees F) and shall possess temperature stability above and below 27 degrees C (80 degrees F) of at least 1 percent per 5 degrees C (10 degrees F). Separate meters shall be 63.5 mm (2-1/2 inch) nominal size or larger.

2.2.1.4 Circuit Breaker

A one, two, or three-pole, flush-mounted, fully magnetic, properly rated non-terminal type circuit breaker shall be installed in the primary circuit of the rectifier supply transformer.

2.2.1.5 Fuses

Cartridge-type fuses with suitable fuse holders shall be provided in each leg of the dc circuit.

2.2.2 Cabinet Construction

Cabinet shall be constructed of not thinner than 1.56 mm (16 gauge), hot dipped galvanized steel or aluminum, and shall be provided with a full door. The enclosure shall have oil-resistant gasket. The door shall be hinged and have a hasp that will permit the use of a padlock. The cabinet shall be fitted with screened openings of the proper size to provide for adequate cooling. Holes, conduit knockouts, or threaded hubs of sufficient size and number shall be conveniently located.

2.2.2.1 Wiring Diagram

A complete wiring diagram of the power unit showing both the ac supply and the dc connections to anodes shall be on the inside of the cabinet door. All components shall be shown and labeled.

2.2.2.2 Grounding Provisions

Grounding provisions shall comply with NFPA 70 and UL 467 including a ground terminal in the cabinet. The grounding conductor from the terminal to the earth grounding system shall be solid or stranded copper not smaller than No. 6 AWG. The earth grounding system shall consist of one or more ground rods. Ground rods shall be of copper-clad steel conforming to UL 467, zinc-coated steel conforming to IEEE C135.30 , or solid stainless steel not less than 16 mm (5/8) inch) in diameter by 2.4 m (8 feet) in length, unless otherwise indicated on contract drawings. Rods shall be driven full length into the earth. Sectional type rods may be used.

2.2.2.3 Resistance to Ground

The resistance to ground shall be measured using the fall-of-potential method described in IEEE 81. The maximum resistance of driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, additional rods not less than 1.8 m (6 feet) on centers, or if sectional type rods are used, additional sections may be coupled and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

2.2.2.4 Cabinet Paint System

The cabinet and mounting support shall be hot dipped galvanized steel or aluminum with the manufacturer's standard painting system. The mounting support for the fiberglass cabinet shall be hot dipped galvanized steel or aluminum with the manufacturer's standard painting system.

2.2.3 Wiring

Wiring shall be installed in accordance with NFPA 70 utilizing type TW or RHW or polyethylene insulation. Fittings for conduit and cable work shall conform to UL 514A. Outlets shall be of the threaded hub type with gasketed covers. Conduit shall be hub type with gasketed covers. Conduit shall be securely fastened at 2.4 m (8 foot) intervals or less. Splices shall be made in outlet fittings only. Conductors shall be color coded for identification. Cable for anode header and distribution shall be No. 2 AWG stranded copper wire with type cathodic protection high molecular weight polyethylene insulation.

2.2.4 Oil Immersed Enclosures

Enclosures shall be of 3.1 mm (11 gauge) steel or heavier, with an accessible drain plug. The oil level shall be clearly marked. The lid shall be hinged and have quick release clamps to secure it in closed position. A stop shall limit the swing of the lid when opened. A compressible, oil resistant, positive sealing gasket shall be provided. The gasket shall return to its original shape upon release of lid pressure. The gasket shall be attached to the tank or lid and joints shall be free of gaps. Base mounting using 102 mm (4 inch) high channels shall be provided. Conduits entering the enclosure shall be internally sealed and shall enter or exit above the oil fill line.

2.3 COKE BREEZE

2.3.1 Calcined Petroleum Coke Breeze (Dry)

Breeze shall conform to the following requirements:

2.3.1.1 Electrical Resistivity

Resistivity shall not exceed 1 milliohm-meter (0.1 ohm-cm) Great Lake Carbon C 12 A Test Method.

2.3.1.2 General Backfill Specifications

Bulk Density - 1044 to 1204 kg/cubic meter (65 to 75 lbs/cubic foot)
Fixed Carbon - 99.0 percent or greater
Volatiles - 0.2 percent or less
Sizing - 100 percent less than 13 mm (1/2 inch)

2.3.2 Metallurgical Coke Breeze (Processed)

Breeze shall conform to the following requirements:

2.3.2.1 Electrical Resistivity (Nominal)

Nominal electrical resistivity shall be:

a. 100 milliohm-meter (10 ohm-centimeter) Max., tightly compacted.

b. 100 milliohm-meter to 150 milliohm-meter, (10 to 15 ohm-centimeter,) lightly compacted.

c. 150 to 200 milliohm-meter, (15 to 20 ohm-centimeter,) loose.

2.3.2.2 General Backfill Specifications

Bulk density - 608 to 672 kg per cubic meter (38 to 42 pounds per cubic foot)
Fixed Carbon - 80 percent or greater
Sizing - 100 percent less than 10 mm (3/8 inch)

2.4 MISCELLANEOUS MATERIALS

Within 30 days after receipt of notice to proceed, submit an itemized list of equipment and materials including item number, quantity, and manufacturer of each item. The list shall be accompanied by a description of procedures for each type of testing and adjustment, including testing of coating for thickness and holidays. Installation of materials and equipment shall not commence until this submittal is approved.

2.4.1 Electrical Wire

2.4.1.1 Anode Connecting Wire

Anode connecting wire shall be No. 8 AWG stranded copper wire with type CP high molecular weight polyethylene insulation, 2.8 mm (7/64 inch) thick, 600 volt rating. Cable-to-anode contact resistance shall be 0.003 ohms maximum. Deep anode ground bed connecting wire shall be No. 8 AWG, stranded copper wire with an inner jacket of 1 mm (40 mils) of Halar insulation covered by an outer jacket of 1.6 mm (65 mils) CP high molecular weight polyethylene insulation, 600 volt rating. Cable-to-anode contact resistance shall be 0.02 ohms maximum.

2.4.1.2 Anode Header Cable

Cable for anode header and distribution shall be No. 8 AWG stranded copper wire with type CP high molecular weight polyethylene, 2.8 mm (7/64 inch) thick insulation , 600-volt rating.

2.4.1.3 Test Wires

Test wires shall be No. 12 AWG stranded copper wire with NFPA 70 Type TW or RHW or polyethylene insulation.

2.4.1.4 Resistance Wire

Resistance wire shall be AWG No. 16 or No. 22 nickel-chromium wire.

2.4.2 Deep Anode Ground Bed Casing

Casing shall be outside diameter as indicated on contract drawings/documents, 3 mm (1/8 inch) minimum wall thickness black steel pipe, conforming to ASTM A53/A53M, Type E or S, Grade B. The top casing shall be outside diameter as indicated on contract drawings/documents, 3 mm (1/8 inch) minimum wall thickness black steel pipe, conforming to ASTM A53/A53M, Type E or S, Grade B. The metal casing shall extend no more than 1.5 m (5 feet)) below the top of a well cap.

2.4.3 Anode Centering Device for Deep Anode Ground Beds

Anode centering device shall be nonmetallic and capable of maintaining centering in the hole without interfering with other anode lead wiring, until coke breeze is packed in place.

2.4.4 Conduit

Nonmetallic conduit shall conform to NEMA TC 2.

2.4.5 Test Boxes and Junction Boxes

Boxes shall be outdoor type conforming to UL 514A.

2.4.6 Vent Pipes

All deep wells shall be vented in anode zones. Openings in the vent shall not be larger than 0.1524 mm (0.006 inch).

2.4.7 Polyethylene Insulation

Polyethylene insulation shall comply with the requirements of ASTM D1248 and of the following types, classes, and grades:

2.4.7.1 High Molecular Weight Polyethylene

High molecular weight polyethylene shall be Type I, Class C, Grade E5.

2.4.7.2 High Density Polyethylene

High density polyethylene shall be Type III, Class C, Grade E3.

2.4.8 Test Stations

Provide test stations complete with an insulated terminal block having the indicated number of terminals; provided with a lockable cover and have a cast-in legend, "C.P. Test" and complete with an insulated terminal block having the required number of terminals. (One terminal required for each conductor). Provide sufficient test stations to monitor underground isolation points. Test-bond stations (potential measurement and stray current control) shall be provided to monitor pipe to soil potential of proposed underground pipes or existing underground metallic structures which may conduct stray current from the new cathodic protection system. The location of the test-bond stations shall ensure that the pipe to soil potential of metallic pipe not designated to be protected is not made less negative by the energization of the cathodic protection system. Test station terminal connections and the terminal conductor shall be permanently tagged to identify each termination of the conductors (e.g. identify the conductors connected to the protected structures). Conductors shall be permanently identified in the station by means of plastic or metal tags, or plastic sleeves to indicate termination. Each conductor shall be color coded in accordance with the drawings. The station test facility, including permanent Cu-Cu S04 reference cells and test returns shall be installed as indicated. Pavement inserts shall be nonmetallic and shall allow Cu-Cu S04 reference electrode to contact the electrolyte beneath the pavement surface. Abbreviations shall not be used. Welding of electrical connections shall be as follows: Exothermic welds shall be "CADweld", "Thermo-weld", or approved equal. Use and selection of these materials and welding equipment shall be in accordance with the manufacturer's recommendations.

2.4.9 Calibrated Shunts

Install shunts calibrated in current per potential (e.g. mA/V) between the lead or header wire connected to the anode and the current collector lead connected to the structure. The calibration of the shunt shall be clearly marked and installed to be visible.

2.4.10 Sealing and Dielectric Compound

Sealing and dielectric compound shall be a black, rubber based compound that is soft, permanently pliable, tacky, moldable, and unbacked. Apply compound as recommended by the manufacturer, but not less than 3 mm (1/8 inch) thick.

2.4.11 Protective Covering

Except as otherwise specified, protective covering for underground metallic components including pipe and fittings shall be applied mechanically in a factory or field plant specially equipped for the purpose. Valves and fittings that cannot be coated and wrapped mechanically shall have the protective covering applied by hand, preferably at the plant applying the covering to the pipe. Joints shall be coated and wrapped by hand. Hand coating and wrapping shall produce a covering equal in thickness to the covering applied mechanically. Piping and components installed in valve boxes or manholes shall also receive the specified protective coating.

2.4.11.1 Pipeline Metallic Components

Underground metallic pipelines and structures shall have a good quality factory applied coating. This includes carbon steel, cast iron and ductile iron pipelines or vessels. If nonmetallic pipelines are installed, metallic fittings or pipe sections shall be coated as follows.

a. The nominal thickness of the metallic pipe joint or other component coating shall be 0.6 mm (24 mils), plus or minus 5 percent, unless otherwise indicated on contract drawings/documents.

b. Pipe and joint coating for factory applied or field repair material shall be applied as recommended by the manufacturer and shall be one of the following:

(1) Continuously extruded polyethylene and adhesive coating system.

(2) Polyvinyl chloride pressure-sensitive adhesive tape.

(3) High density polyethylene/bituminous rubber compound tape.

(4) Butyl rubber tape.

(5) Coal tar epoxy.

2.4.11.2 Field Joints

Coat field joints with material compatible with the pipeline coating compound. Apply the joint coating material to an equal thickness as the pipeline coating. Unbonded coatings shall not be used on buried metallic piping. This prohibition includes unbonded polymer wraps or tubes.

2.4.11.3 Inspection of Pipe Coatings

Once the pipeline or vessel is set in the trench, conduct an inspection of the coating including electrical holiday detection as described in paragraph TESTS AND MEASUREMENTS.

2.4.11.4 Above Ground Piping System

Above ground piping shall be given two coats of exterior oil paint. Surface preparation shall be as recommended by paint manufacturer, except as follows: ferrous, shop primed surfaces shall be touched up with ferrous metal primer; surfaces that have not been shop primed shall be solvent cleaned; surfaces that contain loose rust, mil scale, or other foreign substances shall be mechanically cleaned by power wire brushing and primed with ferrous metal primer; and primed surfaces shall be finished with two coats of exterior oil paint or vinyl paint.

2.4.12 Preformed Sheaths

Preformed sheaths for encapsulating electrical wire splices to be buried underground shall fit the insulated wires entering the spliced joint.

2.4.13 Epoxy Potting Compound

Epoxy potting compound for encapsulating electrical wire splices to be buried underground shall be a two package system made for the purpose.

2.4.14 Backfill Shields

Backfill shields shall consist of approved pipeline wrapping or fiberglass reinforced, coal-tar impregnated tape, or plastic weld caps, specifically made for the purpose.

2.4.15 Electrical Tape

Pressure-sensitive vinyl plastic electrical tape shall conform to UL 510.

2.4.16 Cable Marker Tape

Traceable marker tape shall be manufactured for the purpose and clearly labeled "Cathodic Protection Cable Buried Below".

2.4.17 Electrically Isolating Pipe Joints

Electrically isolating pipe joints for above or below ground use shall be flexible, mechanical pipe couplings of an electrically isolating type consisting of bolted or compression design provided with electrically isolating joint harness if required to provide pull-out strength, flexible, integral electrically isolating pipe couplings designed for field installation by means of a swaging system and providing pull-out strength with a factor of safety, nonflexible flanged type electrically isolating pipe joints to be field assembled, or nonflexible factory assembled electrically isolating pipe joints designed with stub ends for installation by welding and providing pull-out strength with a factor of safety.

2.4.17.1 Threaded Fittings

Threaded type electrically isolating pipe joints shall have molded plastic screw threads and be used above ground only. Machined plastic screw threads shall not be used.

2.4.17.2 Electrically Isolating Pipe Joints

Electrically isolating pipe joints shall be of a type that is in regular factory production.

2.4.18 Electrically Conductive Couplings

Electrically conductive couplings shall be of a type that has a published maximum electrical resistance rating given in the manufacturer's literature. Cradles and seals shall be of a type that is in regular factory production made for the purpose of electrically isolating the carrier pipe from the casing and preventing the incursion of water into the annular space.

2.4.19 Joint and Continuity Bonds

Provide bonds across joints or any electrically discontinuous connections in the piping, and other pipes and structures with other than welded or threaded joints included in this cathodic protection system. Unless otherwise specified, bonds between structures and across joints in pipe with other than welded or threaded joints shall be with No. 4 AWG stranded copper cable with polyethylene insulation. Bonds between structures shall contain sufficient slack for any anticipated movement between structures. Bonds across pipe joints shall contain a minimum of 100 mm (4 inch) of slack to allow for pipe movement and soil stress. Bonds shall be attached by exothermic welding. Exothermic weld areas shall be insulated with coating compound and approved by the Contracting Officer. Continuity bonds shall be installed as necessary to reduce stray current interference. Additional joint bonding shall be done where determined during construction or testing or as directed. Joint bonding shall include excavation and backfilling. There shall be a minimum of 2 continuity bonds between each structure and other than welded or threaded joints. Electrical continuity shall be tested across joints with other than welded or threaded joints and across metallic portions of sewage lift stations and water booster stations.

2.4.19.1 Resistance Bonds

Resistance bonds shall be adjusted for minimum interference while achieving the criteria of protection. Alternate methods may be used when approved.

2.4.19.2 Stray Current Measurements

Perform stray current measurements as indicated. Alternate methods may be used when approved. The stray current test report shall indicate location of test, type of pipes tested, and method of testing.

2.4.20 Electrical Isolation of Structures

Isolating fittings, including isolating flanges and couplings, shall be installed above ground or in a concrete hand hole. As a minimum, isolating flanges or unions shall be provided at the following locations:

a. Connection of new piping to existing pipes.

b. Pressure piping under floor slab to a building.

Additionally, isolation shall be provided between new pipe lines and foreign pipes that cross the new lines within 3 m (10 feet).

2.5 MAGNESIUM ANODES

Weights and dimensions of magnesium anodes shall be approximately as follows:

TYPICAL MAGNESIUM ANODE SIZES
(Cross sections may be round, square, or D shaped)

NOMINAL WT. kg.	APPROX. SIZE (mm)	NOMINAL GROSS WT kg PACKAGED IN BACKFILL	NOMINAL PACKAGE DIMENSIONS (mm)
1.4	76 X 76 X 127	3.6	133 X 133 X 203
2.3	76 X 76 X 203	5.9	133 X 133 X 286
4.1	76 X 76 X 356	12.3	133 X 508
5.5	102 X 102 X 305	14.5	191 X 457
7.7	102 X 102 X 432	20.5	191 X 610
14.5	127 X 127 X 521	30.9	216 X 711
22.7	178 X 178 X 406	45.5	254 X 610

TYPICAL MAGNESIUM ANODE SIZES
(Cross sections may be round, square, or D shaped)

NOMINAL WT. LBS.	APPROX. SIZE (IN)	NOMINAL GROSS WT LBS PACKAGED IN BACKFILL	NOMINAL PACKAGE DIMENSIONS (IN)
3	3 X 3 X 5	8	5 1/4 X 5 1/4 X 8
5	3 X 3 X 8	13	5 1/4 X 5 1/4 X 11 1/4
9	3 X 3 X 14	27	5 1/4 X 20
12	4 X 4 X 12	32	7 1/2 X 18
17	4 X 4 X 17	45	7 1/2 X 24
32	5 X 5 X 20 1/2	68	8 1/2 X 28
50	7 X 7 X 16	100	10 X 24

2.5.1 Composition

Anode shall be of high potential magnesium alloy, made of primary magnesium obtained from sea water or brine, and not from scrap metal. Magnesium anodes shall conform to ASTM B843 and to the following analysis unless otherwise indicated:

Element	Percent by Weight
Aluminum	0.02 maximum
Manganese	1.50 maximum
Zinc	0.05
Silicon	0.10 maximum
Copper	0.02 maximum
Nickel	0.002 maximum
Iron	0.03 maximum
Impurities	0.30 maximum
Magnesium	Remainder

Furnish spectrographic analyses on samples from each heat or batch of anodes used on this project.

2.5.2 Packaged Anodes

Provide anodes in packaged form with the anode surrounded by specially prepared quick-wetting backfill and contained in a cloth or paper sack. Anodes shall be centered in the backfill material. The backfill material shall have the following composition, unless otherwise indicated.

Material	Percent by Weight
Gypsum	75
Bentonite	20
Sodium Sulfate	5

2.5.3 Lead Wires

Anode lead wires shall consist of No. 10 solid copper wire, with TW insulation. Lead wires shall be not less than 3 m (10 feet) in length, without splices.

2.5.4 Connection Wires

Wires shall consist of No. 10 solid copper wire with RHW-USE or polyethylene insulation.

2.5.5 Insulation

Type RHW-USE insulation shall comply with NFPA 70. Polyethylene insulation shall comply with ASTM D1248; high molecular weight polyethylene shall be Type I, Class C, Grade E5; high density polyethylene shall be Type III, Class C, Grade E3.

2.5.6 Conduit Steel

Conduit steel shall conform to UL 6 and ANSI C80.1.

2.5.7 Tape

Pressure-sensitive vinyl plastic electrical tape shall conform to UL 510.

2.5.8 Backfill Shields

Provide shields consisting of approved wrapping of reinforced fiberglass coal-tar impregnated tape, or plastic weld caps specifically made for the purpose and installed in accordance with the manufacturer's recommendations. When joint bonds are required, due to the use of mechanical joints, the entire joint shall be protected with kraft paper joint cover. The joint cover shall be filled with poured hot coal-tar enamel.

2.5.9 Electrical Connections

Electrical connections shall be done as follows:

a. Exothermic welds shall be "Cadweld" or Burndy "Thermo-Weld" or approved equal. Use of these materials shall be in accordance with the manufacturer's recommendations.

b. Electrical shielded arc welds on steel pipe shall be approved via shop drawing action.

c. Other methods of welding shall be specifically approved for use by the pipe manufacturer.

2.5.10 Anode Installation

Anode configuration and size shall be as indicated on contract drawings/documents. Details shown are indicative of the general type of material required and are not intended to restrict selection of materials or of any particular manufacturer. The anode system shall be designed for a life of 25 years of continuous operation.

2.6 LEAD WIRE CONNECTIONS

Lead wire to structure connections shall be by exothermic welding process. Weld charges made specifically for use on cast iron shall be used on cast iron pipe. A backfill shield filled with a pipeline mastic sealant or material compatible with the coating shall be placed over the weld connection and shall cover the exposed metal adequately.

PART 3 EXECUTION

3.1 CRITERIA OF PROTECTION

Acceptance criteria for determining the adequacy of protection on a buried pipe or tank shall be in accordance with NACE SP0169, and NACE RP0193, and as specified below.

3.1.1 Iron and Steel

Use the following method a. for testing cathodic protection voltages. If more than one method is required, use method b.

a. A negative voltage of at least minus 850 millivolts as measured between the pipe, tank, or specified underground component and a saturated copper-copper sulphate reference electrode contacting the (electrolyte) earth directly over the pipe, tank, or specified underground component. Determination of this voltage shall be made with the cathodic protection system in operation. Voltage drops shall be considered for valid interpretation of this voltage measurement. A minimum of minus 850 millivolts "instant off" potential between the structure, pipe, tank, or specified underground component being tested and the reference cell shall be achieved over 95 percent of the area of the structure. Obtain adequate number of measurements over the entire structure, pipe, tank, or other metallic component to verify and record achievement of minus 850 millivolts "instant off". This potential shall be obtained over 95 percent of the total metallic area without the "instant off" potential exceeding 1200 millivolts.

b. A minimum polarization voltage shift of 100 millivolts as measured between the pipe or tank and a saturated copper-copper sulphate reference electrode contacting the earth directly over the pipe or tank. This polarization voltage shift shall be determined by interrupting the protective current and measuring the polarization decay. When the protective current is interrupted, an immediate voltage shift will occur. The voltage reading, after the immediate shift, shall be used as the base reading from which to measure polarization decay. Measurements achieving 100 millivolts shall be made over 95 percent of the metallic surface.

3.1.2 Aluminum

Aluminum pipes and tanks shall not be protected to a potential more negative than minus 1200 millivolts, measured between the pipe or tank and a saturated copper-copper sulphate reference electrode contacting the earth, directly over the pipe, tank, or metallic component. Resistance, if required, shall be inserted in the anode circuit within the test station to reduce the potential of the aluminum pipe or tank to a value which will not exceed a potential more negative than minus 1200 millivolts. Voltage shift criterion shall be a minimum negative polarization shift of 100 millivolts measured between the pipe, tank, or metallic component and a saturated copper-copper sulphate reference electrode contacting the earth, directly over the pipe or tank. The polarization voltage shift shall be determined as outlined for iron and steel.

3.1.3 Copper Piping

For copper piping the following criteria shall apply. A minimum of 100 millivolts of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The polarization voltage shift shall be determined as outlined for iron and steel.

3.2 GROUND BED INSTALLATION

3.2.1 Shallow Ground Beds

Shallow ground beds shall contain size and quantity of anodes designed to meet performance criteria of the cathodic protection system at an initial operating current output density not exceeding 40 percent of maximum recommended current output density.

3.2.1.1 Horizontally Buried Bare Anodes

Horizontally buried bare anodes shall be bedded on and covered with metallurgical coke breeze in a trench excavated for the purpose at depths, spacing and locations as shown. Anodes shall be completely surrounded by the backfill at bottom, sides, and top for a distance of not less than 100 mm (4 inch). Backfill shall be compacted.

3.2.1.2 Vertically Buried Bare Anodes

Vertically buried bare anodes shall be installed in vertical holes in the ground having a depth, spacing, and location shown. The holes in the ground shall be sufficiently large to provide an annular space around the anode not less than 100 mm (4 inch). The anodes shall be centered in the hole and backfilled with calcined petroleum coke breeze or metallurgical coke breeze. Backfill shall be compacted.

3.2.1.3 Horizontally Buried Canister-Contained Anodes

Horizontally buried canister-contained anodes shall be buried in a trench excavated for the purpose at depths, spacing, and locations shown.

3.2.1.4 Vertically Buried Canister-Contained Anodes

Vertically buried canister-contained anodes shall be installed in vertical holes in the ground having depth, spacing, and locations shown. The holes in the ground shall be sufficiently larger in diameter than the canisters to facilitate easy lowering into the hole and backfilling. The space between the canister and the wall of the hole shall be completely backfilled with a wet slurry of earth free of stones.

3.2.1.5 Cable Protection

Positive cable to the ground bed and negative cable to the pipe or tank to be protected shall be buried a minimum depth of 750 mm (30 inch) except where above ground construction utilizing conduit is used.

3.2.1.6 Multiple Anode Systems

Multiple anode systems shall consist of groups of anodes connected in parallel to a header cable, buried in the ground at depths, spacing, and locations shown. The anodes shall be buried horizontally or vertically, as indicated on contract drawings/documents.

3.2.1.7 Distributed Anode Systems

Distributed anode systems shall consist of a line or row of anodes connected in parallel to a header cable and buried in the ground parallel to the pipeline. The anodes shall be at the pipeline at depths, spacing, and locations shown. The anodes shall be buried horizontally or vertically, as indicated on contract drawings/documents.

3.2.2 Deep Anode Ground Beds

Deep anode ground beds shall consist of an installation of anodes supported one above the other and supported in place by a method that does not suspend the anodes from the connecting cable. Deep anode ground beds shall be installed in accordance with NACE SP0572 and as specified in these specifications.

3.2.2.1 Anode Centering

Anodes shall be centered in the well by means of centering devices.

3.2.2.2 Casing

The casing shall be to depth and elevation as indicated on contract drawings/documents.

3.2.2.3 Casing Insulation

The portion of casing above the top anode shall be coated with an electrically insulating underground type coating.

3.2.2.4 Anode Requirements

Anode sizes, spacing, number of anodes, depth of well, and other details shall be as shown.

3.2.2.5 Anode Lead Wire

Each anode shall have a separate, continuous wire extending from the anode to the junction box at the well head.

3.2.2.6 Anode Cables

Anode cables shall terminate in a nearby junction box, equipped with individual anode current shunts. Where full length casing is used, two wire connections from casing shall terminate in the junction box.

3.2.2.7 Anode and Cable Installation

If the method of installation utilizes backfill support for anodes and cable, provide slack in the cable near each anode and increase the cable insulation in thickness from 2.8 to 4.0 mm (7/64 to 5/32 inch) utilizing an approved composite of plastic and elastomeric materials.

3.2.2.8 Backfill

Backfill the well with calcined petroleum coke breeze or metallurgical coke breeze surrounding the anodes by a method that does not leave voids or bridging. The recommended method is to pump the backfill from the bottom upward. The well shall be over-filled with coke breeze allowing for settlement so that the settled level after a number of days is as high as the level shown. The number of days allowed for settling of the coke breeze will be determined by the Contracting Officer. If the top level of coke breeze is below the level shown after settlement, put additional coke breeze in the well. The backfill used shall not require tamping. The top portion of the well shall be sealed for 8 m (25 feet) to prevent surface water run-off. All vents shall be vented above the high water mark and at a safe height.

3.2.2.9 Cable Marker Tape

Locate traceable marker tape in the same trench above cathodic protection cables including structure leads, anode leads, anode header cables, test station leads, bonding cables, and rectifier electrical power cables.

3.2.2.10 Pavement Inserts

Install pavement inserts at a minimum of 30 m (100 foot) intervals for pipelines. The pavement inserts shall be installed directly over the structure being protected and tested.

3.3 MAGNESIUM ANODE INSTALLATION

Installation shall not proceed without the presence of the Contracting Officer, unless otherwise authorized. Anode locations may be changed to clear obstructions when approved. Install anodes in sufficient number and of the required type, size, and spacing to obtain a uniform current distribution surface on the structure. Prepackaged anodes shall be installed as shown on the drawings.

3.3.1 Installation of Packaged Anodes

Install packaged anodes completely dry, lower them into holes by rope sling or by grasping the cloth gather. The anode lead wire shall not be used in lowering the anodes. Backfill the hole with fine soil in 150 mm (6 inch) layers and each layer shall be hand-tamped around the anode. The tamper shall not strike the anode or lead wire. If immediate testing is to be performed, add water only after backfilling and tamping has been completed to a point 150 mm (6 inch) above the anode. Approximately 8 L (2 gallons) of water shall be poured into the hole; after the water is absorbed by the soil, backfilling and tamping shall be completed to the top of the hole. Anodes shall be installed as shown. When rock is found prior to achieving specified depth, anode may be installed horizontally to a depth at least as deep as the bottom of the pipe, with the approval of the Contracting Officer.

3.3.2 Underground Metal Pipe Line

Install anodes 610 mm (2 feet) below the line to be protected unless otherwise noted on the drawings. To facilitate periodic electrical measurements during the life of the sacrificial anode system and to reduce the output current of the anodes if required, anode lead wires in a single group of anodes shall be buried a minimum of 610 mm (2 feet) and each anode lead wire shall be connected to an individual terminal in a test station. The anode lead cable shall make contact with the structure only through a test station. Resistance wire shall be installed between the anode lead cable and the pipe cable in the test station to reduce the current output, if required.

3.3.3 Lead and Resistance Wire Splices

Lead wire splicing, when necessary, shall be made with copper split bolt connectors of proper size. The joint shall be carefully wrapped with at least 3 layers of electrical tape. Resistance wire connections shall be done with silver solder and the solder joints wrapped with a minimum of 3 layers of pressure-sensitive tape.

3.3.4 Magnesium Anodes for Metallic Components

As a minimum, each metallic component shall be protected with 2 4.1 kg (9 lb) magnesium anodes located on each side of the metallic component and routed through a test station. Fire hydrant pipe component shall have a minimum of 2 4.1 kg (9 lb) magnesium anodes routed through a test station for each hydrant. Pipe under concrete slab shall have a minimum of 5 7.7 kg (17 lb) anodes for each location where metal pipe enters the building under the slab. A permanent reference cell shall be provided adjacent to the pipe entrance to the slab. Conductors shall be routed to a test station. Each valve shall have a minimum of 2 4.1 kg (9 lb) magnesium anodes routed through a test station. Sections of metallic pipe 6.1 m (20 foot) long, when used where force mains are within 3 m (10 feet) of the water pipe, shall have a minimum of 4 7.7 kg (17 lb) anodes.

3.4 MISCELLANEOUS INSTALLATION

3.4.1 Rectifier Installation

Mounting shall be as shown. Pole or wall mounting shall be equipped with a channel bracket, lifting eyes, and a keyhole at the top. Cross-arm brackets shall accommodate a 102 by 102 mm (4 by 4 inch) cross-arm.

3.4.2 Wire Connections

3.4.2.1 Wire Splicing

Connecting wire splicing shall be made with copper compression connectors or exothermic welds, following instructions of the manufacturer. Split-bolt type connectors shall not be used.

3.4.2.2 Steel Surfaces

Connections to ferrous pipe or metal tanks shall be made by exothermic weld methods as manufactured by an approved manufacturer for the type of pipe or tank. Electric arc welded connections and other types of welded connections to ferrous pipe and structures shall be approved before use.

3.4.3 Pipe Joints

3.4.3.1 Electrical Continuity

Underground pipe shall be electrically continuous except at places where electrically isolating joints are specified. Pipe joined by means other than welding shall meet the following electrical continuity requirements:

a. Mechanical joints that are not factory designed to provide electrical continuity shall be bonded by installing a metallic bond across the joint. The bonding connections shall be made by the exothermic welding process.

b. Mechanical joints designed to provide electrical continuity may be used.

3.4.3.2 Electrical Isolation of Structures

Perform electrical isolation of structures as follows:

a. Isolating Fittings: Isolating flanges and couplings shall be installed aboveground, or within manholes, wherever possible, but an isolating device that electrically separates a pipeline shall not be installed in a confined area where a combustible atmosphere may collect unless precautions are taken to prevent arcing such as by means of externally located surge arresters, grounding cells, or other means. Isolating flanges and couplings in lines entering buildings shall be located at least 300 mm (12 inch) above grade or floor level. Pipelines entering buildings either below or above ground shall be electrically isolated from the structure wall with an electrically isolating wall sleeve.

b. Gas Distribution Piping: Electrical isolation shall be provided at each building riser pipe to the pressure regulator, at all points where a short circuit to another structure or to a foreign structure may occur, and at other locations as indicated.

c. Steam, High Temperature, or Chilled Water, Line, Supply and Return Piping, and Line Conduit: Electrical isolation shall be provided at each building entrance, and at other locations as indicated.

d. Fuel, Gasoline, Storage Tanks, or Fire Suppression: Electrical isolation shall be provided in each pipe at the building or tank as shown.

e. Copper Piping: Copper piping shall be wrapped with pipeline tape and electrically isolated at both ends.

f. Underground Storage Tanks (UST): Tanks shall be electrically isolated from other metallic structures. Components protected with the tank such as pipes, vents, anchors, and fill pipes shall be bonded to the tank.

3.4.4 Dissimilar Metals

Buried piping of dissimilar metals including new and old steel piping, excepting valves, shall be electrically separated by means of electrically insulating joints at every place of connection. The insulating joint, including the pipes, shall be coated with an underground type dielectric coating for a minimum distance of 10 diameters on each side of the joint.

3.4.5 Ferrous Valves

Dissimilar ferrous valves in a buried ferrous pipeline, including the pipe, shall be coated with an underground type dielectric coating for a minimum distance of 10 diameters on each side of the valve.

3.4.6 Brass or Bronze Valves

Brass or bronze valves shall not be used in a buried ferrous pipeline.

3.4.7 Metal Pipe Junction

If the dissimilar metal pipe junction, including valves, is not buried and is exposed to atmosphere only, the connection or valve, including the pipe, shall be coated with an underground type dielectric coating for a minimum distance of 3 diameters on each side of the junction.

3.4.8 Casing

Where a pipeline is installed in a casing under a roadway or railway, the pipeline shall be electrically isolated from the casing, and the annular space sealed against incursion of water.

3.4.9 Test Stations

Test stations shall be of the type and location shown and shall be curb box mounted. Buried electrically isolating joints shall be provided with test wire connections brought to a test station. Changes in designated location shall have prior approval. Unless otherwise shown, other test stations shall be located as follows:

a. At 300 m (1,000 foot) intervals or less.

b. Where the pipe or conduit crosses any other metal pipe.

c. At both ends of casings under roadways and railways.

d. Where both ends of an insulating joint are not accessible above ground for testing purposes.

3.5 TRAINING COURSE

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 16 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. Submit the proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions. At least 14 days prior to date of proposed conduction of the training course, submit the training course curriculum for approval, along with the proposed training date. Training shall consist of demonstration of test equipment, providing forms for test data and the tolerances which indicate that the system works satisfactorily.

3.6 TESTS AND MEASUREMENTS

Submit test reports in booklet form tabulating field tests and measurements performed, upon completion and testing of the installed system and including close interval potential survey, casing and interference tests, final system test verifying protection, insulated joint and bond tests, and holiday coating test. Submit a certified test report showing that the connecting method has passed a 120-day laboratory test without failure at the place of connection, wherein the anode is subjected to maximum recommended current output while immersed in a 3 percent sodium chloride solution. Each test report shall indicate the final position of controls. For Air Force projects, Contractor shall prepare and submit one hard copy and one digital copy of Air Force Form 491 for the Air Force facility. Instructions for completing this form are in UFC 3-570-06 APPENDIX A PART 2. If the cathodic protection test is completed before the entire project is finished, contractor shall complete and submit the form monthly until the contract is completed.

3.6.1 Baseline Potentials

Each test and measurement will be witnessed by the Contracting Officer. Notify the Contracting Officer a minimum of 5 working days prior to each test. After backfill of the pipe, tank, and anodes is completed, but before the anodes are connected to the pipe or tank, the static potential-to-soil of the pipe and tank shall be measured. The locations of these measurements shall be identical to the locations specified for pipe-to-reference tank-to-reference electrode potential measurements.

3.6.2 Isolation Testing

Before the anode system is connected to the pipe or tank, an isolation test shall be made at each isolating joint or fitting. This test shall demonstrate that no metallic contact, or short circuit exists between the two isolated sections of the pipe or tank. Any isolating fittings installed and found to be defective shall be reported to the Contracting Officer.

3.6.2.1 Insulation Checker

Use a Model 601 insulation checker, as manufactured by "Gas Electronics" or an approved equal, for isolating joint (flange) electrical testing in accordance with manufacturer's operating instructions. An isolating joint that is good will read full scale on the meter; if an isolating joint is shorted, the meter pointer will be deflected at near zero on the meter scale. Location of the fault shall be determined from the instructions and the joint shall be repaired. If an isolating joint is located inside a vault, the pipe shall be sleeved with insulator when entering and leaving the vault.

3.6.2.2 Cathodic Protection Meter

Use a Model B3A2 cathodic protection meter, as manufactured by "M. C. Miller" or an approved equal using the continuity check circuit for isolating joint (flange) electrical testing. Perform this test in addition to the Model 601 insulation checker. Continuity is checked across the isolated joint after the test lead wire is shorted together and the meter adjusted to scale. A full scale deflection indicates the system is shorted at some location. The Model 601 verifies that the particular insulation under test is good and the Model B3A2 verifies that the system is isolated. If the system is shorted, further testing shall be performed to isolate the location of the short.

3.6.3 Anode Output

After the rectifier is energized, the current output of the individual anode leads shall be measured by using an approved method. This may be done with a shunt and MV meter, a low-resistance ammeter, or a clamp-on milliammeter. The total current shall be measured and compared to the sum of all anode currents and to the rectifier output current. If an individual anode output current meets or exceeds the recommended output for that anode, the system shall be turned down or balancing resistors installed. Calculation of the wattage of the resistors shall be sufficient to handle the maximum load which will be encountered on the anode lead. All measurements obtained, the date, time, and locations of all measurements shall be recorded.

3.6.4 Electrode Potential Measurements

Upon completion of the installation and with the entire cathodic protection system in operation, electrode potential measurements shall be made using a copper-copper sulphate reference electrode and a potentiometer-voltmeter, or a direct current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements shall be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements shall be recorded. No less than 8 measurements shall be made over any length of line or component. Additional measurements shall be made at each distribution service riser, with the reference electrode placed directly over the service line.

3.6.5 Location of Measurements

3.6.5.1 Coated Piping or Conduit

For coated piping or conduit, take measurements from the reference electrode located in contact with the earth, directly over the pipe. Connection to the pipe shall be made at service risers, valves, test leads, or by other means suitable for test purposes. Pipe to soil potential measurements shall be made at intervals not exceeding 30 m (100 feet). The Contractor may use a continuous pipe to soil potential profile in lieu of 0.75 m (2.5 ft) interval pipe to soil potential measurements. Additional measurements shall be made at each distribution service riser, with the reference electrode placed directly over the service line adjacent to the riser. Potentials shall be plotted versus distance to an approved scale. Locations where potentials do not meet or exceed the criteria shall be identified and reported to the Contracting Officer.

3.6.5.2 Underground Tanks

For underground tanks, make a minimum of three measurements taken from the reference electrode located:

a. Directly over the center of the tank.

b. At a point directly over the tank and midway between each pair of anodes.

c. At each end of the tank.

3.6.6 Casing Tests

Before final acceptance of the installation, the electrical separation of carrier pipe from casings shall be tested and any short circuits corrected.

3.6.7 Interference Testing

Before final acceptance of the installation, interference tests shall be made with respect to any foreign pipes and tanks in cooperation with the owner of the foreign pipes and tanks. A full report of the tests giving all details shall be made.

3.6.8 Holiday Test

Repair any damage to the protective covering, during transit and handling, before installation. After field coating and wrapping has been applied, inspect the entire pipe by an electric holiday detector with impressed current in accordance with NACE SP0188 using a full ring, spring type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective covering shall be repaired upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer to determine suitability of the detector. Furnish labor, materials, and equipment necessary for conducting the inspection. Inspect the coating system for holes, voids, cracks, and other damage during installation.

3.6.9 Recording Measurements

Record all pipe-to-soil and tank-to-soil potential measurements including initial potentials where required. Locate, correct and report to Contracting Officer any short circuits to foreign pipes and tanks encountered during checkout of the installed cathodic protection system. Pipe-to soil and tank-to-soil potential measurements are required on as many pipes and tanks as necessary to determine the extent of protection or to locate short-circuits.

-- End of Section --

SECTION 26 51 00

INTERIOR LIGHTING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A580/A580M	(2014) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2009a; R 2014) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B633	(2013) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings

GREEN SEAL (GS)

GS-12	(1997) Occupancy Sensors

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011) IES Lighting Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI C78.901	(2005) American National Standard for Electric Lamps - Single Base Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI C82.4	(2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.81	(2013) American National Standard for Electric Lamps--Double-Capped Fluorescent Lamps--Dimensional and Electrical Characteristics
NEMA ANSLG C82.11	(2011) Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts
NEMA C136.10	(2010) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA LL 1	(1997; R 2002) Procedures for Linear Fluorescent Lamp Sample Preparation and the TCLP Extraction

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 1029	(1994; Reprint Dec 2013) High-Intensity-Discharge Lamp Ballasts
UL 1598	(2008; Reprint Oct 2012) Luminaires
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 595	(1985) Marine-Type Electric Lighting Fixtures
UL 773	(1995; Reprint Mar 2002) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2006; Reprint Nov 2013) Standard for Nonindustrial Photoelectric Switches for Lighting Control
UL 844	(2012) Standard for Luminaires for Use in Hazardous (Classified) Locations
UL 924	(2006; Reprint Apr 2014) Standard for Emergency Lighting and Power Equipment
UL 935	(2001; Reprint Aug 2014) Standard for Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

Materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Lighting fixtures and accessories mounted on exterior surfaces of buildings are specified in this section.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. Average life is the time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

c. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SYSTEM DESCRIPTION

1.4.1 Lighting Control System

Provide lighting control system as indicated. Lighting control equipment shall include, if indicated: control modules, power packs, dimming ballasts, occupancy sensors, and light level sensors.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Data, drawings, and reports shall employ the terminology, classifications, and methods prescribed by the IES HB-10, as applicable, for the lighting system specified.

SD-03 Product Data

Fluorescent lighting fixtures

Fluorescent electronic ballasts

Fluorescent lamps

Metal-halide lamps; G

Exit signs

Emergency lighting equipment; G

Central emergency system; G

Occupancy sensors

Electronic dimming ballast

Dimming ballast controls

Energy Efficiency

SD-06 Test Reports

Operating test

Submit test results as stated in paragraph entitled "Field Quality Control."

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein, showing all light fixtures, control modules, control zones, occupancy sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

1.6 QUALITY ASSURANCE

1.6.1 Fluorescent Electronic Ballasts

Submit ballast catalog data as required in the paragraph entitled "Fluorescent Lamp Electronic Ballasts" contained herein. As an option, submit the fluorescent fixture manufacturer's electronic ballast specification information in lieu of the actual ballast manufacturer's catalog data. This information shall include published specifications and sketches, which covers the information required by the paragraph entitled "Fluorescent Lamp Electronic Ballasts" herein. This information may be supplemented by catalog data if required, and shall contain a list of vendors with vendor part numbers.

1.6.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.3.3 Energy Efficiency

Comply with National Energy Policy Act and Energy Star requirements for lighting products. Submit documentation for Energy Star qualifications for equipment provided under this section. Submit data indicating lumens per watt efficiency and color rendition index of light source.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.1 Electronic Ballast Warranty

Furnish the electronic ballast manufacturer's warranty. The warranty period shall not be less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2 PRODUCTS

2.1 FLUORESCENT LIGHTING FIXTURES

UL 1598. Fluorescent fixtures shall have electronic ballasts unless specifically indicated otherwise.

2.1.1 Fluorescent Lamp Electronic Ballasts

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with UL 935, NEMA ANSLG C82.11, NFPA 70, and CEC Title 24 unless specified otherwise. Ballast shall be 100 percent electronic high frequency type with no magnetic core and coil components. Ballast shall provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum).

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast shall have light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp.

e. Ballast factor shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

f. Ballast shall be UL listed Class P with a sound rating of "A."

g. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

h. Ballasts shall be programmed start unless otherwise indicated. Programmed start ballasts may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

i. Ballasts for compact fluorescent fixtures shall be programmed start.

j. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA ANSLG C78.81 and ANSI C78.901 as applicable.

k. Ballast shall be capable of starting and maintaining operation at a minimum of minus 17 degrees C (0 degrees F) unless otherwise indicated.

l. Electronic ballast shall have a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.1.1.1 T-8 Lamp Ballast

a. Total harmonic distortion (THD): Shall be 20 percent (maximum).

b. Input wattage.

1. 32 watts (maximum) when operating one F32T8 lamp

2. 62 watts (maximum) when operating two F32T8 lamps

3. 92 watts (maximum) when operating three F32T8 lamps

4. 114 watts (maximum) when operating four F32T8 lamps

d. Provide three and four lamp fixtures with two ballasts per fixture where multilevel switching is indicated.

e. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.

2.1.1.2 F17T8 Lamp Ballast

a. Total harmonic distortion (THD): Shall be 25 percent (maximum).

b. Input wattage:

1. 34 watts (maximum) when operating two F17T8 lamps.

2.1.1.3 T-5 Long Twin Tube Lamp Ballast

a. Total harmonic distortion (THD): Shall not be greater than 25 percent when operating one lamp, 15 percent when operating two lamps, and 20 percent when operating three lamps.

b. Input wattage:

1. 45 watts (maximum) when operating one F40 T-5 lamps

2. 74 watts (maximum) when operating two F40 T-5 lamps

3. 105 watts (maximum) when operating three F40 T-5 lamps

c. Provide three and four lamp fixtures with two ballasts per fixture where multilevel switching is indicated.

d. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.

2.1.1.4 F96T8 Lamp Ballast

a. Total harmonic distortion (THD): Shall not be greater than 30 percent when operating one lamp and 20 percent when operating two lamps.

b. Input wattage:

1. 56 watts (maximum) when operating one F96T8 lamps

2. 102 watts (maximum) when operating two F96T8 lamps

c. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.

2.1.2 Fluorescent Lamp Electronic Dimming Ballast

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with NEMA ANSLG C82.11, UL 935, and NFPA 70, unless specified otherwise. Ballast shall provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast dimming capability range shall be from 100 to 5 percent (minimum range) of light output, flicker free. Ballast shall start lamp at any preset light output setting without first having to go to full light output. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum) at full light output, and 0.90 (minimum) over the entire dimming range.

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast factor at full light output shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

e. Ballast shall be UL listed Class P with a sound rating of "A".

f. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

g. Ballast shall be programmed start. Ballast may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

h. Ballasts for compact fluorescent fixtures shall be programmed start.

i. Ballast shall be capable of starting and maintaining operation at a minimum of minus 17 degrees C (0 degrees F) unless otherwise indicated.

j. Total harmonic distortion (THD): Shall be 20 percent (maximum) over the entire dimming range.

k. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA ANSLG C78.81 and ANSI C78.901 as applicable.

2.1.2.1 T-8 Lamp Ballast

Input wattage, for indicated lamp quantity shall be:

a. 35 watts (maximum) when operating one F32T8 lamp.

b. 70 watts (maximum) when operating two F32T8 lamps.

c. 104 watts (maximum) when operating three F32T8 lamps.

2.1.3 Dimming Ballast Controls

The dimming ballast controls shall be a slide dimmer with on/off control. The slide dimmer shall be compatible with the ballast and control the ballast light output over the full dimming range. Dimming ballast controls shall be approved by the ballast manufacturer.

2.1.4 Light Level Sensor

UL listed. Light level sensor shall be capable of detecting changes in ambient lighting levels, shall provide a dimming range of 20 percent to 100 percent, minimum, and shall be designed for use with dimming ballast and voltage system to which they are connected. Sensor shall be capable of controlling 40 electronic dimming ballast, minimum. Sensor light level shall be adjustable and have a set level range from 100 to 1000 lux (10 to 100 foot-candles), minimum. Sensor shall have a bypass function to electrically override sensor control.

2.1.5 Fluorescent Lamps

a. T-8 rapid start low mercury lamps shall be rated 32 watts (maximum), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours. Low mercury lamps shall have passed the EPA Toxicity Characteristic Leachate

Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.

b. T-8 rapid start lamp, 17 watt (maximum), nominal length of 610 mm (24 inches), 1300 initial lumens, CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours.

c. T-8 instant start lamp, 59 watts (maximum), nominal length of 2438 mm (96 inches), minimum CRI of 75, 5700 initial lumens, color temperature of 3500 K, and average rated life of 15,000 hours.

d. T-5, long twin tube fluorescent lamp, 40 watts (maximum), 3500 K, 574 mm (22.6 inches) maximum length, 20,000 hours average rated life, 3150 initial lumens, CRI of 80 (minimum), 2G11 Type base, 90 to 100 lumens/watt depending on wattage.

e. T-8, U shaped fluorescent lamp, 31 watts maximum, 2600 initial lumens (minimum), 3500 K, 75 CRI (minimum), 20,000 hours average rated life, 41.29 mm (1.625 inch) leg spacing.

f. Compact fluorescent lamps shall be: CRI 80, minimum, 3500 K, 10,000 hours average rated life, and as follows:

   1. T-4, twin tube, rated 5 watt, 250 initial lumens (minimum) 7 watts, 400 initial lumens (minimum), 9 watts, 600 initial lumens (minimum), and 13 watts, 825 initial lumens (minimum), as indicated.

   2. T-4, double twin tube, rated 13 watts, 900 initial lumens (minimum), 18 watts, 1200 initial lumens (minimum), and 26 watts, 1800 initial lumens (minimum), as indicated.

Average rated life is based on 3 hours operating per start.

2.1.6 Compact Fluorescent Fixtures

Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Providing assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall use lamps as indicated, with a minimum CRI of 80.

2.1.7 Open-Tube Fluorescent Fixtures

Provide with self-locking sockets, or lamp retainers (two per lamp). Provide lamps with shatter resistant coating, non-yellowing, nominal thickness of 0.38 mm (15 mils), and with 97 percent (minimum) light transmission. Provide a clear polycarbonate protective sleeve with end caps, over lamp, with 95 percent (minimum) light transmission. The sleeve shall be rated to withstand the thermal profile of the lamp and ballast.

2.1.8 Air Handling Fixtures

Fixtures used as air handling registers shall meet requirements of NFPA 90A.

2.2 HIGH-INTENSITY-DISCHARGE (HID) LIGHTING FIXTURES

UL 1598. Provide HID fixtures with tempered glass lenses when using metal-halide lamps.2.2.1 HID Ballasts

UL 1029 and ANSI C82.4 and shall be constant wattage autotransformer (CWA) or regulator, high power factor type (minimum 90 percent). Provide single-lamp ballasts which shall have a minimum starting temperature of minus 30 degrees C. Ballasts shall be:

a. Designed to operate on the voltage system to which they are connected.

b. Designed for installation in a normal ambient temperature of 40 degrees C.

c. Constructed so that open circuit operation will not reduce the average life.

2.2.2 Metal-Halide Lamps

Single ended or double-ended and wattage as indicated on contract drawings/documents, conforming to ANSI/ANSLG C78.43 or ANSI C78.1381, as applicable.

2.3 RECESS- AND FLUSH-MOUNTED FIXTURES

Provide type that can be relamped from the bottom. Access to ballast shall be from the bottom. Trim for the exposed surface of flush-mounted fixtures shall be as indicated.

2.4 SUSPENDED FIXTURES

Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers shall be shock-absorbing type where indicated. Hangers shall allow fixtures to swing within an angle of 0.79 rad (45 degrees). Brace pendants 1219 mm (4 feet) or longer provided in shops or hangers to limit swinging. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 4.57 mm (0.18 inch) diameter.

2.5 FIXTURES FOR HAZARDOUS LOCATIONS

In addition to requirements stated herein, provide fluorescent or HID incandescent fixtures for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated. Fixture shall also conform to UL 595 for marine environments as indicated.

2.6 SWITCHES

2.6.1 Toggle Switches

Provide toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.6.2 Incandescent Dimmer Switch

UL 20, single-pole, 600 watt, 120 volt ac, full-range rotary on-off type with built-in electromagnetic interference filter.

2.7 LIGHTING CONTACTOR

NEMA ICS 2, electrically or mechanically held contactor. Contacts shall be rated as indicated on contract drawings/documents. Coils shall be rated as indicated on contract drawings/documents. Provide in NEMA 1 or 4 enclosure conforming to NEMA ICS 6. Contactor shall have silver alloy double-break contacts and coil clearing contacts for mechanically held contactor. Provide contactor with hand-off-automatic selector switch.

2.8 TIME SWITCH

Astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at predetermined time between 8:30 p.m. and 2:30 a.m. or sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise. Provide switch having automatically wound spring mechanism or capacitor, to maintain accurate time for a minimum of 15 hours following power failure. Provide time switch with a manual on-off bypass switch. Housing for the time switch shall be surface or flush-mounted, NEMA 1 or 3 enclosure conforming to NEMA ICS 6.

2.9 PHOTOCELL SWITCH

UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell with single-throw contacts or single pole double-throw (SPDT) contacts for control of mechanically held contactors, rated 1000 W. Switch shall turn on at or below 32 lux (3 foot-candles) and off at 22 to 107 lux (2 to 10 foot-candles). A time delay shall prevent accidental switching from transient light sources. Provide switch:

a. Integral to the luminaire, rated 1000W minimum. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

b. In a U.V. stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.

c. In a high-impact-resistant, noncorroding and nonconductive molded plastic housing with a locking-type receptacle conforming to NEMA C136.10, rated 1800 VA, minimum.

d. In a cast weatherproof aluminum housing with adjustable window slide, rated 1800 VA, minimum.

2.10 POWER HOOK FIXTURE HANGERS

Provide UL listed assembly including through-wired power hook housing, interlocking plug and receptacle, power cord, and fixture support loop. Power hook housing shall be cast aluminum having two 19 mm (3/4 inch) threaded hubs. Support hook shall have safety screw. Fixture support loop shall be cast aluminum with provisions for accepting 19 mm (3/4 inch) threaded fixture stems. Power cord shall include 410 mm (16 inches) of 3 conductor No. 16 Type SO cord. Assembly shall be rated 120 volts or 277 volts, 20 amperes or 480 volts, 20 amperes.

2.11 EXIT SIGNS

UL 924, NFPA 70, and NFPA 101. Exit signs shall be self-powered remote-powered type. Exit signs shall use no more than 5 watts.

2.11.1 Self-Powered LED Type Exit Signs (Battery Backup)

Provide with automatic power failure device, test switch, pilot light, integral self-testing module and fully automatic high/low trickle charger in a self-contained power pack. Battery shall be sealed electrolyte type, shall operate unattended, and require no maintenance, including no additional water, for a period of not less than 5 years. LED exit sign shall have emergency run time of 1 1/2 hours (minimum). The light emitting diodes shall have rated lamp life of 70,000 hours (minimum).

2.11.2 Remote-Powered Exit Signs

Provide remote ac/dc exit signs with provisions for wiring to external ac and dc power sources. Provide signs with a minimum of two ac lamps for normal illumination and a minimum of two dc lamps for emergency lighting.

2.12 EMERGENCY LIGHTING EQUIPMENT

UL 924, NFPA 70, and NFPA 101. Provide lamps in wattage indicated. Provide accessories required for remote-mounted lamps where indicated. Remote-mounted lamps shall be as indicated.

2.12.1 Emergency Lighting Unit

Provide as indicated. Emergency lighting units shall be rated for 12 volts, except units having no remote-mounted lamps and having no more than two unit-mounted lamps may be rated 6 volts. Equip units with brown-out sensitive circuit to activate battery when ac input falls to 75 percent of normal voltage. Provide integral self-testing module.

2.12.2 Fluorescent Emergency System

Each system shall consist of an automatic power failure device, test switch operable from outside of the fixture, pilot light visible from outside the fixture, and fully automatic solid-state charger in a self-contained power pack. Provide self-testing module integral to the fixture. Charger shall be either trickle, float, constant current or constant potential type, or a combination of these. Battery shall be sealed electrolyte type with capacity as required to supply power to the number of lamps shown for each system for 90 minutes at a minimum of 400 lumens per lamp output. Battery shall operate unattended and require no maintenance, including no additional water, for a period of not less than 5 years. Emergency ballasts provided with fixtures containing solid-state ballasts shall be fully compatible with the solid-state ballasts.

2.13 SELF-TESTING MODULE

Self-testing module for exit signs and emergency lighting equipment shall perform the following functions:

a. Continuous monitoring of charger operation and battery voltage with visual indication of normal operation and of malfunction.

b. Monthly discharge cycling of battery with monitoring of transfer circuit function, battery capacity and emergency lamp operation with visual indication of malfunction. The battery capacity test may be conducted by using a synthetic load.

c. Manual test switch to simulate a discharge test cycle.

d. Module shall have low voltage battery disconnect (LVD) and brown-out protection circuit.

2.14 CENTRAL EMERGENCY SYSTEM

Each system shall supply emergency power, wattage and voltage as indicated on contract drawings/documents, 60 Hz sine wave ac unless otherwise indicated, for a minimum period of 90 minutes. Sine wave ac system shall have an inverter output distortion of not more than 10 percent at unity power factor. The system shall be designed to handle surges during loss and recovery of power.

2.14.1 Operation

With normal power applied, batteries shall be automatically charged. Upon loss of normal power, system shall automatically disengage from the normal input line and switch to a self-contained inverter within 1 second when serving incandescent and fluorescent lamps. Inverter shall have built-in protection when output is shorted or overloaded. When normal power resumes, the emergency system shall automatically switch back to normal operation before the power loss. Size transfer switch for this function to handle 125 percent of full load.

2.14.2 Battery Charger

Provide two-rate charger for lead-calcium batteries. The charger shall be solid-state, completely automatic, maintaining the batteries in a fully charged condition, and recharging the batteries to full capacity as specified in UL 924.

2.14.3 Batteries

Batteries shall be sealed lead-calcium type, shall operate unattended, and shall require no maintenance, including no additional water, for a period of not less than 5 years.

2.14.4 Accessories

Provide visual indicators to indicate normal power, inverter power, and battery charger operation. Provide test switch to simulate power failure by interrupting the input line, battery voltage meter, load ammeter, automatic brown-out circuitry to switch to emergency power when input line voltage drops below 75 percent of normal value, electrolyte level detector that will activate a visual or audio alarm in the event of a low water condition, and low voltage cutoff (LVD) to disconnect inverter when battery voltage drops to approximately 80 percent of nominal voltage.

2.14.5 Enclosure

Provide a free-standing cabinet with floor stand. Cabinet construction shall be of 14 gage sheet steel with baked-on enamel finish and locking type latch.2.15 OCCUPANCY SENSORS

UL listed. Comply with GS-12. Occupancy sensors and power packs shall be designed to operate on the voltage indicated. Sensors and power packs shall have circuitry that only allows load switching at or near zero current crossing of supply voltage. Occupancy sensor mounting as indicated. Sensor shall have an LED occupant detection indicator. Sensor shall have adjustable sensitivity and adjustable delayed-off time range of 5 minutes to 15 minutes. Wall mounted sensors shall be white. Ceiling mounted sensors shall have 6.28 rad (360 degree) coverage unless otherwise indicated.

a. Ultrasonic sensor shall be crystal controlled and shall not cause detection interference between adjacent sensors.

b. Infrared sensors shall have a daylight filter. Sensor shall have a fresnel lens that is applicable to space to be controlled.

c. Ultrasonic/Infrared Combination Sensor

d. Microwave and audiophonic sensors.

Occupancy detection to turn lights on requires both ultrasonic and infrared sensor detection. Lights shall remain on if either the ultrasonic or infrared sensor detects movement. Infrared sensor shall have lens selected for indicated usage and daylight filter to prevent short wavelength infrared interference. Ultrasonic sensor frequency shall be crystal controlled.

2.16 SUPPORT HANGERS FOR LIGHTING FIXTURES IN SUSPENDED CEILINGS

2.16.1 Wires

ASTM A641/A641M, galvanized regular coating, soft temper, 2.68 mm (0.1055 inches) in diameter (12 gage).

2.16.2 Wires, for Humid Spaces

ASTM A580/A580M, composition 302 or 304, annealed stainless steel 2.68 mm (0.1055 inches) in diameter (12 gage).

2.16.3 Straps

Galvanized steel, 25 by 4.76 mm (one by 3/16 inch), conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.16.4 Rods

Threaded steel rods, 4.76 mm (3/16 inch) diameter, zinc or cadmium coated.

2.17 EQUIPMENT IDENTIFICATION

2.17.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.17.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires shall be clearly marked for operation of specific lamps and ballasts according to proper lamp type.

a. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

b. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

c. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.

d. ANSI ballast type (M98, M57, etc.) for HID luminaires.

e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

All markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.18 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15 percent of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. Provide 10 percent spare lamps of each type from the original manufacturer.

3.1.2 Lighting Fixtures

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Installation shall meet requirements of NFPA 70. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures shall be independently supported from the building structure by a minimum of four wires, straps, or rods per fixture and located near each corner of each fixture. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Round fixtures or fixtures smaller in size than the ceiling grid shall be independently supported from the building structure by a minimum of four wires, straps, or rods per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 19 mm (3/4 inch) metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture. Provide wires, straps, or rods for lighting fixture support in this section. Lighting fixtures installed in suspended ceilings shall also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

3.1.3 Suspended Fixtures

Suspended fixtures shall be provided with 0.79 rad (45 degree) swivel hangers so that they hang plumb and shall be located with no obstructions within the 0.79 rad (45 degree) range in all directions. The stem, canopy and fixture shall be capable of 0.79 rad (45 degree) swing. Pendants, rods, or chains 1.2 meters (4 feet) or longer excluding fixture shall be braced to prevent swaying using three cables at 2.09 rad (120 degree) separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 3.1 meters (10 feet) or as recommended by the manufacturer, whichever is less.

3.1.4 Ballasts

3.1.4.1 Remote Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp, as designated by the manufacturer.

3.1.4.2 Electronic Dimming Ballasts

All electronic dimming ballasts controlled by the same controller shall be of the same manufacturer. All fluorescent lamps on electronic dimming ballast control shall be seasoned or burned in at full light output for 100 hours before dimming.

3.1.5 Exit Signs and Emergency Lighting Units

Wire exit signs and emergency lighting units ahead of the switch to the normal lighting circuit located in the same room or area.

3.1.5.1 Exit Signs

Wire exit signs on separate circuits and serve from a separate breaker. Signs shall have only one control, which shall be the separate breaker. Paint control device red and provide lockout.

3.1.5.2 Emergency Lighting from Central Emergency System

Wire emergency lighting powered from a central emergency system as indicated on the drawings.

3.1.6 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.

3.1.7 Occupancy Sensor

Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage shall provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage. Set sensor "on" duration to 10 minutes.

3.1.8 Light Level Sensor

Locate light level sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for 50 foot-candles (500 lux) or for the indicated light level at the typical work plane for that area.

3.2 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.3.1 Electronic Dimming Ballast

Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.

3.3.2 Occupancy Sensor

Test sensors for proper operation. Observe for light control over entire area being covered.

-- End of Section --

SECTION 26 56 00

EXTERIOR LIGHTING
05/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO LTS	(2013; Errata 2013) Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 189.1	(2011; Errata 1-2 2012; INT 1 2013; Errata 3-8 2013) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013; Errata 1-3 2013; Errata 4-6 2014; Errata 7 2015) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA U1	(2014) Use Category System: User Specification for Treated Wood

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B108/B108M	(2014) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM C1089	(2013) Standard Specification for Spun Cast Prestressed Concrete Poles

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80	(2008) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2010; Addendum A 2008; Addenda B & C 2009) Nomenclature and Definitions for Illuminating Engineering
IES RP-8	(2014) Roadway Lighting
IES TM-15	(2011) Luminaire Classification System for Outdoor Luminaires
IES TM-21	(2011) Projecting Long Term Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C136.13	(2004; R 2009) American National Standard for Roadway Lighting Equipment, Metal Brackets for Wood Poles
ANSI C136.21	(2004; R 2009) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted

	Luminaires
ANSI C136.3	(2005; R 2009) American National Standard for Roadway and Area Lighting Equipment Luminaire Attachments
ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
ANSI/NEMA C78.LL 1256	(2003) Procedures for Fluorescent Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure (TCLP)
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2011) American National Standard for Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products
NEMA ANSLG C78.380	(2007) Electric Lamps - High Intensity Discharge Lamps, Method of Designation
NEMA ANSLG C78.44	(2008) For Electric Lamps - Double-Ended Metal Halide Lamps
NEMA ANSLG C82.11	(2011) Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts
NEMA C136.20	(2012) American National Standard for Roadway and Area Lighting Equipment - Fiber Reinforced Composite (FRC) Lighting Poles
NEMA C136.31	(2010) American National for Roadway and Area Lighting Equipment - Luminaire Vibration
NEMA C78.LL 3	(2003) Electric Lamps - Procedures for High Intensity Discharge Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure
NEMA C82.77	(2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures

NEMA IEC 60529	(2004) Degrees of Protection Provided by Enclosures (IP Code)
NEMA WD 7	(2011) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1728F-700	(2011) Specification for Wood Poles, Stubs, and Anchor Logs

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1310	(2011; Reprint Dec 2014) UL Standard for Safety Class 2 Power Units
UL 1598	(2008; Reprint Oct 2012) Luminaires
UL 773	(1995; Reprint Mar 2002) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2006; Reprint Nov 2013) Standard for Nonindustrial Photoelectric Switches for Lighting Control
UL 8750	(2009; Reprint May 2014) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment
UL 935	(2001; Reprint Aug 2014) Standard for Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires or lighting equipment are specified in Section(s) 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Luminaires and accessories installed in interior of buildings are specified in Section 26 51 00 INTERIOR LIGHTING .

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings shall be as defined in IEEE 100 and IES RP-16.

b. For HID, fluorescent, and induction luminaire light sources, "Average Rated Life" is the time after which 50 percent of a large group of light sources will have failed and 50 percent will have survived under normal operating conditions.

c. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Photometric Plan; G

LED Luminaire Warranty; G

SD-02 Shop Drawings

Luminaire drawings; G

Poles; G

SD-03 Product Data

Luminaire Light Sources; G

Fluorescent, Induction and LED Luminaires; G

Luminaire Ballasts, Generators and Power Supply Units (Drivers); G

Lighting contactor; G

Time switch; G

Lighting Control Relay Panel; G

Motion Sensor; G

Photocell; G

Concrete poles; G

Aluminum poles; G

Steel poles; G

Fiberglass poles; G

Brackets

SD-05 Design Data

Design Data for luminaires; G

SD-06 Test Reports

LED Luminaire - IES LM-79 Test Report; G

LED Light Source - IES LM-80 Test Report; GOperating test

Submit operating test results as stated in paragraph entitled "Field Quality Control."

SD-07 Certificates

Luminaire Useful Life Certificate; G

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life shall be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions shall be taken into consideration.

SD-08 Manufacturer's Instructions

Concrete poles

Submit instructions prior to installation.

Fiberglass poles

Submit instructions prior to installation.

SD-10 Operation and Maintenance Data

Electronic Ballast Warranty

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data shall accompany shop drawings.

1.5.1.2 Poles

Include dimensions, wind load determined in accordance with AASHTO LTS, pole deflection, pole class, and other applicable information. For concrete poles, include: section and details to indicate quantities and position of prestressing steel, spiral steel, inserts, and through holes; initial prestressing steel tension; and concrete strengths at release and at 28 days.

1.5.2 Pressure Treated Wood Pole Quality

Ensure the quality of pressure treated wood poles. Furnish an inspection report (for wood poles) of an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with AWPA U1 and RUS Bull 1728F-700 standards. The RUS approved Quality Mark "WQC" on each pole will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.5.3 Photometric Plan

For LED luminaires, include computer-generated photometric analysis of the "designed to" values for the "end of useful life" of the luminaire installation using a light loss factor of 0.7. For LED and all other types of luminaires, the submittal shall include the following:

Horizontal illuminance measurements at finished grade, taken at a maximum of every 3050 mm 10 feet.

Vertical illuminance measurements at 1500 mm 5 feet above finished grade.

Minimum and maximum lux foot-candle levels.

Average maintained lux foot-candle level.

Maximum to minimum ratio for horizontal illuminance only.

1.5.4 Design Data for Luminaires

a. Provide distribution data according to IES classification type as defined in IES HB-10.

b. Shielding as defined by IES RP-8 or B.U.G. rating for the installed position as defined by IES TM-15.

c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification per NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

d. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections shall be obtained from testing in accordance with IES LM-80.

e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets shall not exceed maximum rating of pole as installed in particular wind zone area.

1.5.5 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Submittal shall include all photometric and electrical measurements, as well as all other pertinent data outlined under "14.0 Test Report" in

IES LM-79.

1.5.6 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED package, array, or module. Submittal shall include:

a. Testing agency, report number, date, type of equipment, and LED light source being tested.

b. All data required by IES LM-80.

1.5.6.1 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports shall be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.

b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.

c. A manufacturer's in-house lab that meets the following criteria:

   1. Manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires and the manufacturer's lab has been successfully certifying these fixtures for a minimum of 15 years.

   2. Annual equipment calibration including photometer calibration in accordance with National Institute of Standards and Technology.

1.5.7 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.8 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.8.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires for a minimum of 15 years. Products shall have been in satisfactory commercial or industrial use for 15 years prior to bid opening. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 15-year period.

1.5.8.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

1.6.1 Wood Poles

Do not store poles on ground. Stack poles stored for more than 2 weeks on decay-resisting skids arranged to support the poles without producing noticeable distortion. Store poles to permit free circulation of air; the bottom poles in the stack shall be at least 305 mm one foot above ground level and growing vegetation. Do not permit decayed or decaying wood to remain underneath stored poles. Do not drag treated poles along the ground. Do not use pole tongs, cant hooks, and other pointed tools capable of producing indentation more than 25 mm one inch in depth in handling the poles. Do not apply tools to the groundline section of any pole.

1.6.2 Concrete Poles

Do not store poles on ground. Support poles so they are at least 305 mm one foot above ground level and growing vegetation.

1.6.3 Fiberglass, Aluminum, or Steel Poles

Do not store poles on ground. Support poles so they are at least 305 mm one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.1 LED Luminaire Warranty

Provide Luminaire Useful Life Certificate.

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

a. Provide a written five year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

1. Finish warranty shall include warranty against failure and against substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

2. Material warranty shall include:

   (a) All power supply units (drivers).

   (b) Replacement when more than 10 percent of LED sources in any light-bar or subassembly(s) are defective or non-starting.

b. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the Contracting Officer signed warranty certificates prior to final payment.

1.7.2 Electronic Ballast Warranty

Furnish the electronic ballasts manufacturer's warranty. The warranty period shall not be less than five (5) years from the date of manufacture. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed twelve (12) months, thereby permitting four (4) years of the five (5) year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be luminaires, equipment or accessories are specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND, Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and associated equipment and accessories for interior applications are specified in Section 26 51 00 INTERIOR LIGHTING.

2.2 FLUORESCENT, INDUCTION AND LED LUMINAIRES

UL 1598, NEMA C82.77 and UL 8750. Provide luminaires as indicated in luminaire schedule and XL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. All luminaires of the same type shall be provided by the same manufacturer.

2.2.1 General Requirements

a. LED luminaire housings shall be die cast or extruded aluminum. Housings for luminaires other than LED shall be die cast, extruded, or fabricated aluminum. Fabricated aluminum housings shall have all seams and corners internally welded to resist weathering, moisture and dust.

b. LED luminaires shall be rated for operation within an ambient temperature range of minus 30 degrees C minus 22 degrees F to 40 degrees C 104 degrees F.

c. Luminaires shall be UL listed for wet locations per UL 1598. Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per NEMA IEC 60529.

d. LED luminaires shall produce a minimum efficacy as shown in the following table, tested per IES LM-79. Theoretical models of initial raw LED lumens per watt are not acceptable.

Application	Luminaire Efficacy in Lumens per Watt
Exterior Pole/Arm-Mounted Area and Roadway Luminaires	65
Exterior Pole/Arm-Mounted Decorative Luminaires	65
Exterior Wall-Mounted Area Luminaires	60
Bollards	35
Parking Garage Luminaires	70

e. Luminaires shall have IES distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans per IES HB-10.

f. Housing finish shall be baked-on enamel, anodized, or baked-on powder coat paint. Finish shall be capable of surviving ASTM B117 salt fog environment testing for 2500 hours minimum without blistering or peeling.

g. Luminaires shall not exceed the following IES TM-15 Backlight, Uplight and Glare (B.U.G.) ratings:

   1. Maximum Backlight (B) rating shall be determined by lighting zone in which luminaire is placed.

   2. Maximum Uplight (U) rating shall be U0.

   3. Maximum Glare (G) rating shall be determined by lighting zone in which luminaire is placed.

h. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.

i. The finish color shall be as indicated in the luminaire schedule or detail on the project plans.

j. Luminaire arm bolts shall be 304 stainless steel or zinc-plated steel.

k. Luminaire lenses shall be constructed of clear or frosted, as indicated in contract, tempered glass or UV-resistant acrylic. Provide polycarbonate vandal-resistant lenses as indicated.

l. The wiring compartment on pole-mounted, street and area luminaires must be accessible without the use of hand tools to manipulate small screws, bolts, or hardware.

m. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, power supply units, ballasts, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.

n. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.

o. Roadway and area luminaires shall have an integral tilt adjustment of plus or minus 5 degrees to allow the unit to be leveled in accordance with ANSI C136.3.

p. Luminaire must pass 3G vibration testing in accordance with NEMA C136.31.

q. All factory electrical connections shall be made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

2.2.2 Luminaire Light Sources

2.2.2.1 Metal Halide (MH) Light Sources

ANSI/ANSLG C78.43, NEMA ANSLG C78.44, ANSI C78.1381, and NEMA ANSLG C78.380. Provide type and wattage as indicated in luminaire schedule on project plans. Open fixtures are prohibited unless provided with a mechanism to utilize only Type O light sources and prohibit the use of Type E or S light sources. Light sources shall be specifically suited to operate in the burning position which they are installed, and shall be compliant with the most current TCLP test procedure per NEMA C78.LL 3 at the time of manufacture.

a. All probe-start metal halide light sources shall utilize a BT, ED, or ET-type envelope, with an E-39 screw base, unless otherwise indicated on contract drawings. The arc tube shall be a ceramic-fused quartz-type, with a wattage rating and minimum initial lumens output as indicated on contract drawings. The correlated color temperature (CCT) shall be 3000 degrees K, with a minimum color rendering index (CRI) of 65, unless otherwise indicated on contract drawings. The minimum average rated life shall be 15,000 hours, based on 10 hours operation per start.

b. All pulse-start metal halide light sources shall utilize envelope, base, and arc tube type, and initial lumens output as indicated on contract drawings. Correlated color temperature (CCT) shall be 3000 degrees K, minimum color rendering index (CRI) shall be 80 , with a minimum average rated life of 12,000 hours, based on 10 hours operation per start, unless otherwise indicated on contract drawings .

2.2.2.2 Fluorescent Light Sources

a. T5HO fluorescent light sources shall have miniature bi-pin bases, be low-mercury type, in nominal length(s) of 1170 mm 46 in 1475 mm 58 in, rated wattage as indicated on drawings, with minimum initial output of 4450 lumens, unless otherwise indicated. Light source correlated color temperature (CCT) shall be 4100 degrees K, with a minimum CRI value of 75, and a minimum average rated life of 25,000 hours, based on 3 hours operation per start. Light sources shall be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at time of manufacture.

b. Compact fluorescent (CFL) light sources shall be 4-pin base, low-mercury, programmed-start, energy-savings type, rated at 26, 32, 42, 57, or 70 watts as indicated on contract drawings, correlated color temperature of 4100 degrees K, unless otherwise indicated on contract drawings, minimum CRI of 82, with an average rated life of 16,000 hours minimum. Light sources shall be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at time of manufacture.

2.2.2.3 Induction Light Sources

Induction light sources shall consist of an electrodeless, inductively-coupled, phosphor-coated fluorescent envelope rated at 55, 85, 100, 150, or 165 watts, as indicated, color temperature of 4000/4100 degrees K, minimum CRI of 80, with an average rated life of 100,000 hours minimum based on 3 hours operation per start.

2.2.2.4 LED Light Sources

a. Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377:

Nominal CCT: 4000 degrees K: 3985 plus or minus 275 degrees K

b. Color Rendering Index (CRI) shall be:

Greater than or equal to 70 for 4000 degrees K light sources.

c. Color Consistency:

Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

2.2.3 Luminaire Ballasts, Generators and Power Supply Units (Drivers)

2.2.3.1 Fluorescent Ballasts

UL 935, NEMA ANSLG C82.11, NFPA 70 and CEC Title 24, with no magnetic core and coil components, and shall meet the following requirements:

a. Shall provide transient protection as recommended by IEEE C62.41.1 and IEEE C62.41.2.

b. Shall be programmed-start or instant-start type as indicated in luminaire schedule on project drawings elsewhere in this specification.

c. Shall be UL listed Class P, have a Class A sound rating, and have a minimum power factor of 0.98.

d. Shall be designed for the wattage and quantity of light sources powered in the luminaire specified, and have circuit diagrams and lamp connection information printed on the exterior of the ballast housing.

e. Shall contain no PCBs and be RoHS compliant.

f. Shall be manufactured in an ISO 9001-certified facility.

g. Shall operate at a frequency greater than 20 kHz minimum, preferably greater than 40 kHz, and shall have a Lamp Current Crest Factor less than 1.7.

h. Shall have a light regulation of plus or minus 10 percent of lumen output when operated within a plus or minus 10 percent range of input voltage.

i. Shall have a full replacement warranty of 5 years from date of manufacture for a maximum case temperature of 70 degrees C 158 degrees F and 3 years for a maximum case temperature of 90 degrees C 194 degrees F.

j. All ballasts provided to operate 1220 mm 48 in T8 light sources shall be NEMA Premium type.

2.2.3.1.1 T5HO Electronic Fluorescent Ballasts

Shall be programmed-start type with nominal ballast factor of 1.0, maximum input current THD of 10 percent, lamp end of life protection circuitry, and have a minimum starting temperature of minus 18 degree C 0 degree F.

Ballast efficacy factor (BEF), rated at 120 volts shall be:

Minimum 3.66 for one 24W light source.
Minimum 1.83 for two 24W light sources.
Minimum 2.23 for one 39W light source.
Minimum 1.11 for two 39W light sources.
Minimum 1.62 for one 54W light source.
Minimum 0.83 for two 54W light sources.
Minimum 0.57 for three 54W light sources.
Minimum 0.42 for four 54W light sources.

Input power shall be:

Maximum 30 watts for one 24W light source.
Maximum 59 watts for two 24W light sources.
Maximum 47 watts for one 39W light source.
Maximum 90 watts for two 39W light sources.
Maximum 63 watts for one 54W light source.
Maximum 120 watts for two 54W light sources.
Maximum 184 watts for three 54W light sources.
Maximum 240 watts for four 54W light sources.

2.2.3.1.2 T8 Electronic Fluorescent Ballasts

Shall be programmed-start or instant-start type, as indicated, with minimum ballast factor of 0.87, maximum current THD of 10 percent, and have a minimum starting temperature of minus 18 degrees C 0 degrees F.

For programmed-start ballasts:

Ballast efficacy factor (BEF), rated at 120 volts shall be:

Minimum 2.9 for one 32 W, 1220 mm 48 in light source (NEMA Premium).
Minimum 1.49 for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
Minimum 1.03 for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
Minimum 0.8 for four 32 W, 1220 mm 48 in light sources (NEMA Premium).

Input power shall be:

Maximum 35 watts for one 32 W, 1220 mm 48 in light source (NEMA Premium).
Maximum 59 watts for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
Maximum 85 watts for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
Maximum 112 watts for four 32 W, 1220 mm 48 in light sources (NEMA Premium).

For instant-start ballasts:

Ballast efficacy factor (BEF), rated at 120 volts shall be:

Minimum 2.9 for one 32 W, 1220 mm 48 in light source (NEMA Premium).
Minimum 1.49 for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
Minimum 1.03 for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
Minimum 0.8 for four 32 W, 1220 mm 48 in light sources (NEMA Premium).
Minimum 1.36 for one 59 W, 2438 mm 96 in light source.
Minimum 0.77 for two 59 W, 2438 mm 96 in light sources.

Input power shall be:

Maximum 35 watts for one 32 W, 1220 mm 48 in light source (NEMA Premium).
Maximum 59 watts for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
Maximum 85 watts for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
Maximum 112 watts for four 32 W, 1220 mm 48 in light sources (NEMA Premium).
Maximum 72 watts for one 59 W, 2438 mm 96 in light source.
Maximum 113 watts for two 59 W, 2438 mm 96 in light sources.

2.2.3.1.3 Compact Fluorescent (CFL) Electronic Ballasts

Shall be programmed start type with ballast factor greater than or equal to 0.98, maximum input current THD of 10 percent, lamp end of life protection circuitry, and have a minimum starting temperature of minus 18 degrees C 0 degrees F for primary light source(s).

The ballast efficacy factor rated at 120 volts shall be:

Minimum 3.64 for one 26W CFL light source.
Minimum 2.72 for one 32W CFL light source.
Minimum 2.13 for one 42W CFL light source.
Minimum 1.56 for one 57W CFL light source.
Minimum 1.28 for one 70W CFL light source.

The input power shall be:

Maximum 29 watts for one 26W CFL light source.
Maximum 36 watts for one 32W CFL light source.
Maximum 46 watts for one 42W CFL light source.
Maximum 59 watts for one 57W CFL light source.
Maximum 75 watt for one 70W CFL light source.

2.2.3.2 Induction Generators

Generator shall be connected to, and operate in conjunction with, an inductive power coupler or coil(s). These in turn activate a glass light source enclosure from either inside or outside of the enclosure. The generator shall be solid-state, high-frequency (200kHz - 2.67MHz) type, with a power factor greater than 0.9, a Class A sound rating, a maximum input current THD of 15 percent, an operating voltage of 120-277V and a minimum starting temperature of minus 40 degrees C minus 40 degrees F. Generator shall be dimmable to 50 percent of lumen output and be UL, CSA, and RoHS compliant.

2.2.3.3 LED Power Supply Units (Drivers)

UL 1310. LED Power Supply Units (Drivers) shall meet the following requirements:

a. Minimum efficiency shall be 85 percent.

b. Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent.

c. Shall be rated to operate between ambient temperatures of minus 30 degrees C minus 22 degrees F and 40 degrees C 104 degrees F.

d. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.

e. Operating frequency shall be: 50 or 60 Hz.

f. Power Factor (PF) shall be greater than or equal to 0.90.

g. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.

h. Shall meet requirements of 47 CFR 15, Class B.

i. Shall be RoHS-compliant.

j. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.

k. Power supplies in luminaires mounted under a covered structure, such as a canopy, or where otherwise appropriate shall be UL listed with a sound rating of A.

l. Shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system, if indicated on drawings.

m. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

2.2.4 LED Luminaire Surge Protection

Provide surge protection integral to luminaire to meet C Low waveforms as defined by IEEE C62.41.2, Scenario 1, Location Category C.

2.3 EXTERIOR LUMINAIRE CONTROLS

Controls shall comply with ASHRAE 189.1. Provide a control system interface within each luminaire that is compatible with the energy management or control system used by the utility department in charge of the project area for control of site lighting, if indicated.

2.3.1 Photocell

UL 773 or UL 773A. Photocells shall be hermetically sealed, silicon diode light sensor type, rated at wattage and voltage as indicated, 50/60 Hz with single-pole, single or double-throw contacts. Photocell shall be designed to fail to the ON position. Housing shall be constructed of die cast aluminum, unless otherwise indicated, rated to operate within a temperature range of minus 40 to 70 degrees C minus 40 to 158 degrees F. Photocell shall have a 13 mm 1/2 in threaded base for mounting to a junction box or conduit, with swivel base type housing, unless otherwise indicated Photocell shall turn on at 10-30 lux 1-3 foot-candles and turn off at 30 to 150 lux 3 to 15 foot-candles. A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition. Provide photocell with metal oxide varistor (MOV) type surge protection.

2.3.2 Timeswitch

Timeswitch shall be an electronic type with a astronomic programming function that changes on/off settings according to seasonal variations of sunset and sunrise, providing a total of 56 on/off set points. Digital clock display format shall be24 hour type. Provide power outage backup for switch utilizing a capacitor or alkaline or lithium battery, which provides coverage for a minimum of 7 days. Timeswitch shall provide control to 4 channels or loads. Contacts shall be rated for 30 amps at 120-277 VAC resistive load in a normally closed (NC) configuration, unless otherwise indicated. Provide switch with function that allows automatic control to be skipped on certain selected, days of the week manual bypass or remote override control, daylight savings time automatic adjustment, and ability for photosensor input, as indicated..

Timeswitch shall be housed in a surface-mounted, lockable NEMA 1 or 3R enclosure, as indicated, constructed of painted steel or plastic polymer conforming to NEMA ICS 6.

2.3.3 Lighting Contactor

NEMA ICS 2. Provide a electrically-held lighting contactor housed in a NEMA 1, 3R, or 4 enclosure, as indicated, conforming to NEMA ICS 6. Contactor shall have 4 poles, configured as normally closed (NC), unless otherwise indicated. Contacts shall be rated 600 volts, 30 amperes for a resistive load, unless otherwise indicated. Coil operating voltage shall be as indicated. Contactor shall have silver cadmium oxide double-break contacts and shall require no arcing contacts. Provide contactor with hand-off-automatic selector switch. Provide contactor as specified above along with disconnect switch or circuit breaker in integral NEMA 1 or 3R enclosure, as indicated, with flange-mounted handle to satisfy requirement for a "combination lighting contactor" when specified.

2.3.4 Lighting Control Relay Panel

Panel shall consist of a single NEMA 1 or 3R, flush or surface-mounted, as indicated, enclosure with two separate interior sections; one for Class 1 (branch circuit) and one for Class 2 (low voltage) wiring. Provide panel with 8 relays, unless otherwise indicated. Panel shall be designed as a stand alone or automated control system interface type, as indicated. The Class 1 section shall contain the load side of all relays and the incoming branch circuit wiring. The Class 2 section shall contain the control power transformer (24 volt output), relays, relay control modules, and control wiring, and nativeLONworks field-programmable application controller for panels connected to the facility automated control system, if indicated on drawings. Panel enclosure shall be constructed of 16 gauge cold-rolled steel with baked-on enamel finish. Panel shall meet requirements of UL 916, ASHRAE 90.1 - SI ASHRAE 90.1 - IP, CEC Title 24 and 47 CFR 15.

Relays shall be 2-pole, rated at 20 amperes 480 VAC with rated life of 120,000 mechanical operations minimum, unless otherwise indicated.

Relay control module shall be 24 volt, electronic type and control up to 16 separate relays (16 channel) or programmed groups of relays. Provide with inputs for signals from devices such as photocells, time clocks, and motion sensors. Relay control module with integral time clock function shall be 24 volt, electronic type with LCD display and control up to 8 separate relays (8 channel).

2.3.5 Motion Sensor

NEMA WD 7, UL 773A. Provide dual technology passive infrared/microwave type sensors with 270 degree coverage, time delay that can be adjusted from 15 seconds to 15 minutes, and "fail to ON position" default state. Sensors shall be located to achieve coverage of areas as indicated on project plans. Coverage patterns shall be derated as recommended by manufacturer based on mounting height of sensor and any obstructions such as trees. Do not use gross rated coverage in manufacturer's product literature. Sensors installed integral to the luminaire must be provided by the luminaire manufacturer. Sensors shall have an integral light level sensor that does not allow luminaires to operate during daylight hours and shall be designed to operate on a voltage of 120/277 VAC, unless otherwise indicated. Provide sensors to operate in conjunction with bi-level controllers that lower HID or LED luminaires to a 50 percent output. Sensor shall be equipped with a threaded base for mounting to a weatherproof junction box.

2.4 POLES

Provide poles designed for wind loading of 161 km/hr 100 miles per hour determined in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be embedded or anchor-base type designed for use with underground or overhead supply conductors, as indicated. Poles, other than wood poles, shall have oval-shaped handhole having a minimum clear opening of 65 by 130 mm 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws. Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

2.4.1 Concrete Poles

Provide concrete poles conforming to ASTM C1089. Cross-sectional shape shall be round, unless otherwise indicated.

2.4.1.1 Steel Reinforcing

Prestressed concrete pole shafts shall be reinforced with steel prestressing members. Design shall provide internal longitudinal loading by either pretensioning or post tensioning of longitudinal reinforcing members.

2.4.1.2 Tensioned Reinforcing

Primary reinforcement steel used for a prestressed concrete pole shaft shall be tensioned between 60 to 70 percent of its ultimate strength. The amount of reinforcement shall be such that when reinforcement is tensioned to 70 percent of its ultimate strength, the total resultant tensile force does not exceed the minimum section compressive strength of the concrete.

2.4.1.3 Coating and Sleeves for Reinforcing Members

Where minimum internal coverage cannot be maintained next to required core openings, such as handhole and wiring inlet, reinforcing shall be protected with a vapor-proof noncorrosive sleeve over the length without the 13 mm 1/2 inch concrete coverage. Each steel reinforcing member which is to be post-tensioned shall have a nonmigrating slipper coating applied prior to the addition of concrete to ensure uniformity of stress throughout the length of such member.

2.4.1.4 Strength Requirement

As an exception to the requirements of ASTM C1089, poles shall be naturally cured to achieve a 28-day compressive strength of 48.23 MPa 7000 psi. Poles shall not be subjected to severe temperature changes during the curing period.

2.4.1.5 Shaft Preparation

Completed prestressed concrete pole shaft shall have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost, and shall be clean, smooth, and free of surface voids and internal honeycombing. Poles shall not be installed for at least 15 days after manufacture.

2.4.2 Aluminum Poles

Provide aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys. Poles shall be seamless extruded or spun seamless type with minimum 4.8 mm 0.188 inch wall thickness. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Tops of shafts shall be fitted with a round or tapered cover. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel. Aluminum poles and brackets for walkway lighting shall have a uniform satin finish to match fixtures and shall not be painted, unless otherwise indicated. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.

2.4.3 Steel Poles

AASHTO LTS. Provide steel poles having minimum 11-gage steel with minimum yield/strength of 331 MPa 48,000 psi and hot-dipped galvanized in accordance with ASTM A123/A123M factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be anchor bolt mounted type, unless otherwise indicated. Poles shall have tapered tubular members, either round in cross section or polygonal. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1270 mm 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, and length. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 248 MPa 36,000 psi.

2.4.4 Fiberglass Poles

NEMA C136.20. Designed specifically for supporting luminaires and having factory-formed cable entrance and handhole. Resin color shall be as indicated, and pigment shall provide uniform coloration throughout entire wall thickness. Finish surface shall be pigmented polyurethane having a minimum dry film thickness of 0.038 mm 1.5 mils. Polyurethane may be omitted if the surface layer of the pole is inherently ultraviolet inhibited. Minimum fiberglass content shall be 65 percent with resin and pigment comprising the other 35 percent material content.

2.5 BRACKETS AND SUPPORTS

ANSI C136.3, ANSI C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 31.75 mm 1 1/4 inch galvanized steel pipe secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 7320 mm 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

2.6 POLE FOUNDATIONS

Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa 50,000 psi; the top 305 mm 12 inches of the rod shall be galvanized in accordance with ASTM A153/A153M. Concrete shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. Luminaires shall be clearly marked for operation of specific light sources and ballasts according to proper light source type. The following light source characteristics shall be noted in the format "Use Only _____":

a. Light source tube diameter code (e.g. T-5, T-8), tube quantity configuration (e.g. twin, quad, triple), base type (e.g. G24q-2, GX 24 q-4), and nominal wattage for fluorescent and compact fluorescent luminaires.

b. Light source type, wattage, bulb type (e.g. ED17, BD56) and coating (clear or coated) for HID luminaires.

c. Start type (e.g. programmed-start, rapid-start, instant-start) for fluorescent and compact fluorescent luminaires.

e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

Markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.8 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Concrete Poles

Install according to pole manufacturer's instructions.

3.1.2 Fiberglass Poles

Install according to pole manufacturer's instructions.

3.1.3 Aluminum or Steel Poles

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. After installation, paint exposed surfaces of steel poles with two finish coats of exterior oil paint of a color as indicated. Install according to pole manufacturer's instructions. Alterations to poles after fabrication will void manufacturer's warranty and shall not be allowed.

3.1.4 Pole Setting

Depth shall be as indicated. Poles in straight runs shall be in a straight line. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 150 mm 6 inch maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

3.1.5 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations. Mount switch on or beside each luminaire when switch is provided in cast weatherproof aluminum housing with swivel arm.

3.1.6 GROUNDING

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.1.7 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test after 100 hours of burn-in time to show that the equipment operates in accordance with the requirements of this section.

-- End of Section --

SECTION 26 56 20.00 10

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D709	(2013) Laminated Thermosetting Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV

	through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C57.12.50	(1981; R 1998) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Volt 601 to 34,500 Volts
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA FB 1	(2012) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA LA 1	(2009) Standard for Surge Arresters
NEMA PB 1	(2011) Panelboards
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2013) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride

	(PVC) Plastic Utilities Duct for Underground Installations

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20	(2002; E 2004) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 345-67	(1998) REA Specification for Filled Telephone Cables, PE-39

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA 6850.19	(1978) Frangible Coupling
FAA AC 150/5345-10	(2005; Rev F) Specification for Constant Current Regulators and Regulator Monitors
FAA AC 150/5345-12	(2005; Rev E) Specification for Airport and Heliport Beacon
FAA AC 150/5345-13	(2007; Rev B) Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits
FAA AC 150/5345-26	(2008; Rev D) FAA Specification for L-823 Plug and Receptacle, Cable Connectors
FAA AC 150/5345-27	(2013; Rev E) Specification for Wind Cone Assemblies
FAA AC 150/5345-28	(2005; Rev F) Precision Approach Path Indicator (PAPI) Systems
FAA AC 150/5345-3	(2007; Rev F) Specification for L-821 Panels for Control to Airport Lighting
FAA AC 150/5345-42	(2013; Rev G) Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories
FAA AC 150/5345-43	(2006; Rev F) Specification for Obstruction Lighting Equipment
FAA AC 150/5345-44	(2007; Rev H) Specification for Runway and Taxiway Signs
FAA AC 150/5345-45	(2007; Rev C) Low-Impact Resistant (LIR) Structures

FAA AC 150/5345-46	(2009; Rev D) Specification for Runway and Taxiway Light Fixtures
FAA AC 150/5345-47	(2005; Rev B) Specification for Series to Series Isolation Transformers for Airport Lighting Systems
FAA AC 150/5345-5	(2006; Rev B) Specification for Airport Lighting Circuit Selector Switch
FAA AC 150/5345-51	(2005; Rev A) Specification for Discharge-Type Flashing Light Equipment
FAA AC 150/5345-7	(2013; Rev F) Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
FAA AC 150/5370-10	(2009; Rev E) Standards for Specifying Construction of Airports
FAA AC 70/7460-1	(2007; Rev K) Obstruction Marking and Lighting
FAA E-2159	(2004; Rev E) Runway End Identifier Lighting System (REIL)
FAA E-2519	(1972; Rev A) Types I and II
FAA E-2628	(1979; Rev B) Sequenced Flashing Lighting System, Elevated and Semiflush with Dimming and Monitoring
FAA E-2702	(2007; Rev A)Low Impact Resistant (LIR) Structures
FAA E-2756	(2004; Rev B) Four Box Precision Approach Path Indicator (PAPI) without Remote Monitoring Subsystem (RMS)
FAA E-2980	(2005) Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR)
FAA E-982	(2003; Rev J) PAR-56 Lampholder

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jul 2012) Standard for Flexible Metal Conduit
UL 1072	(2006; Reprint Aug 2011) Medium-Voltage Power Cables
UL 360	(2013; Reprint Aug 2014) Liquid-Tight Flexible Steel Conduit
UL 44	(2014; Reprint Jun 2014) Thermoset-Insulated Wires and Cables

UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 8460	(2010) Fittings for Rigid Metal Conduits
KS C 8461	(2010) Surface Accessory for Rigid Metal Conduits

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting and Visual Navigation Aids; G

Composite drawings showing coordination of work of one trade with that of other trades and with the structural and architectural elements of the work. Drawings shall be in sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Drawings shall indicate where conflicts or clearance problems exist between the various trades.

As-Built Drawings; G

Drawings, as specified.

SD-03 Product Data

Materials and Equipment; G

1) A complete itemized listing of equipment and materials proposed for incorporation into the work. Each itemization shall include an item number, the quantity of items proposed, and the name of the manufacturer.

2) Data composed of catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents shall be included.

Protection Plan

Protection plan as specified.

Training

Requirements of training shall be provided 8 weeks before training is scheduled to begin.

Special Tools

List of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

List of Parts

A list of parts and components for the system by manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delays.

Maintenance and Repair

Instructions necessary to check out, troubleshoot, repair, and replace components of the systems, as specified.

Posted Instructions; G

Proposed diagrams, instructions, and other sheets shall be submitted prior to posting.

SD-06 Test Reports

Field Quality Control

Performance test reports, upon completion and testing of the installed system, in booklet form showing all field tests performed to adjust each component and all field tests performed to provide compliance with the specified performance criteria.

Each test shall indicate the final position of controls.

Visual Inspection

Inspection reports prepared and provided as each stage of installation is completed. These reports shall identify the activity by contract number, location, quantity of material placed, and compliance with requirements.

SD-07 Certificates

Qualifications

Certified documentation of qualifications, as specified.

Materials and Equipment; G

When equipment or materials are specified to conform to the standards or publications and requirements of AASHTO, ANSI, ASTM, AEIC, FM, IEEE, IES, NEMA, NFPA, or UL, or to an FAA, FS, or MS, proof that the items furnished under this section conform to the specified requirements shall be included. The label or listing in UL Electrical Constructn or in FM APP GUIDE or the manufacturer's certification or published catalog specification data statement that the items comply with applicable specifications, standards, or publications and with the manufacturer's standards will be acceptable evidence of such compliance. Certificates shall be prepared by the manufacturer when the manufacturer's published data or drawings do not indicate conformance with other requirements of these specifications.

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures

One hard copy and one digital copy of operation and maintenance manuals for the equipment furnished. One complete set shall be furnished prior to performance testing and the remainder shall be furnished upon acceptance. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include conduit and equipment layout and simplified wiring and control diagrams of the system as installed.

1.3 QUALITY ASSURANCE

1.3.1 Code Compliance

The installation shall comply with the requirements and recommendations of

NFPA 70 and IEEE C2 and local codes where required.

1.3.2 Qualifications

a. Submit certification containing the names and the qualifications of persons recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and termination has been adequately trained in the proper techniques and has had at least 3 recent years of experience in splicing and terminating the same or similar types of cables approved for installation. Any person recommended by the Contractor may be required to perform a dummy or practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, provide short sections of the approved types of cables with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types. The certification shall be prepared in conformance with paragraph CERTIFICATES OF COMPLIANCE in the SPECIAL CONTRACT REQUIREMENTS, and shall be accompanied by satisfactory proof of the training and experience of persons recommended by the Contractor as cable installers.

b. The SF sub 6 gas pressurized cable and conduit system installer must be trained and certified in installation of this type of system and must be approved by the manufacturer of the system.

c. Submit one hard copy and one digital copy of qualified procedures and lists of names and identification symbols of qualified welders and welding operators prior to welding operations.

1.3.3 Protection Plan

Submit detailed procedures to prevent damage to existing facilities or infrastructures. If damage does occur, the procedures shall address repair and replacement of damaged property at the Contractor's expense.

1.3.4 Prevention of Corrosion

1.3.4.1 Metallic Materials

Protect metallic materials against corrosion as specified. Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, use fittings conforming to UL 486A-486B.

1.3.4.2 Ferrous Metal Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M.

1.3.5 As-Built Drawings

Submit as-built drawings that provide current factual information including deviations from, and amendments to the drawings and changes in the work, concealed and visible, as instructed. The as-built drawings shall show installations with respect to fixed installations not associated with the systems specified herein. Cable and wire shall be accurately identified as to direct-burial or in conduit and shall locate the connection and routing to and away from bases, housings, and boxes. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, provide one hard copy & one digital copy marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. Correct and return the as-built drawings to the Contracting Officer for approval within 10 calendar days from the time the drawings are returned to the Contractor.

1.4 PROJECT/SITE CONDITIONS

Items furnished under this section shall be specifically suitable for the following unusual service conditions:

1.4.1 Altitude

Any equipment shall be suitable for operation up to an altitude of 3,000 m (10,000 ft).

1.4.2 Other

Material or equipment to be installed underground(in handholes, manholes, or underground vaults) or in light bases shall be suitable for submerged operation.

1.4.3 Additional requirements

If the existing facility is to be operational during construction, a scheduling plan properly coordinated with the airfield or heliport users should be developed and included as part of the bid package. Maximum outage time allowed should be coordinated for critical lighting, visual navigational aids and utility systems. Minimum advance notice for proposed outages should be given. Consider transfer of control from the Control Tower to the alternate control point (vault) to maintain the mission for limited times during construction and to minimize mission disruption and potential cost growth during construction. If this is not possible, the scheduling can be delegated to the construction phase of the project by the following requirements.

Existing airfield, heliport or helipad lighting systems shall remain in operating condition except for minimum interruptions, as approved in writing by the Contracting Officer. Prior to each interruption, all necessary materials and a sufficient labor force shall be assembled to permit completing the work within the scheduled time interval. Under no circumstances shall any of the existing airfield or heliport lighting circuits be left inoperative without making provisions for suitable temporary connections in the affected area or areas. All airfield, heliport, or helipad lighting circuits covered under this contract shall be restored in such a manner that they will be operational at dusk each day. Submit a plan for outages and maintaining lighting and lighting control.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide airfield and heliport lighting and visual navigation aids consisting of airfield and heliport lighting, airfield and heliport marking, obstruction lighting and marking, beacon, wind direction indicator, approach lights, runway lights, taxiway lights, apron lights, visual glide slope indicator, runway end identifier lights, runway distance markers, taxiway signs and the lighting power supply and control.

a. Submit composite drawings showing coordination of work of one trade with that of other trades and with the structural and architectural elements of the work. Drawings shall be in sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Drawings shall indicate where conflicts or clearance problems exist between the various trades.

b. Luminaires fabricated from ferrous metals, unless hot-dip galvanized or of porcelain enamel finish, shall be factory finished with a weather-resistant finish in accordance with paragraphs FACTORY COATING and FINISHING, except exposure shall be 200 hours. Finish color shall be the manufacturer's standard, unless otherwise indicated.

2.2 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

a. Submit a complete itemized listing of equipment and materials proposed for incorporation into the work. Each itemization shall include an item number, the quantity of items proposed, and the name of the manufacturer.

b. Submit data composed of catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents.

c. When equipment or materials are specified to conform to the standards or publications and requirements of AASHTO, ANSI, ASTM, AEIC, FM, IEEE, IES, NEMA, NFPA, or UL, or to an FAA, FS, or MS, submit proof that the items furnished under this section conform to the specified requirements.

d. The label or listing in UL Electrical Constructn or in FM APP GUIDE or the manufacturer's certification or published catalog specification data statement that the items comply with applicable specifications, standards, or publications and with the manufacturer's standards will be acceptable evidence of such compliance.

e. Certificates shall be prepared by the manufacturer when the manufacturer's published data or drawings do not indicate conformance with other requirements of these specifications.

2.3 NAMEPLATES

Each major component of equipment shall have as a minimum the manufacturer's name, address, and catalog or style number on a nameplate securely attached to the item of equipment. Laminated plastic nameplates shall be provided for equipment, controls, and devices to identify function, and where applicable, position. Nameplates shall be 3.2 mm (1/8 inch) thick laminated cellulose paper base phenolic resin plastic conforming to ASTM D709 sheet type, grade ES-3, white with black center core. Surface shall be a matte finish with square corners. Lettering shall be engraved into the black core. Size of nameplates shall be 25.4 by 63.5 mm (1 by 2-1/2 inches) minimum with minimum 6.4 mm (1/4 inch) high normal block lettering. Nameplates provided as indicated. Nameplates shall be fastened to the device with a minimum of two sheet metal screws or two rivets.

2.4 ADDITIONAL REQUIREMENTS

Equipment and materials shall be new unless indicated or specified otherwise. Materials and equipment shall be labeled when approved by Underwriters Laboratories (UL) or Factory Mutual (FM) System. Askarel and insulating liquids containing polychlorinated biphenyls (PCB's) will not be allowed in any equipment. Equipment installed below grade in vaults, manholes, and handholes shall be the submersible type.

2.4.1 Electrical Tape

Electrical tape shall be UL 510 plastic insulating tape.

2.4.2 Conduit, Conduit Fittings, and Boxes

2.4.2.1 Metallic conduit

Rigid galvanized steel conduit shall comply with UL 6 and ANSI C80.1 or KS C 8401. Metallic conduit fittings and outlets shall comply with UL 514A and NEMA FB 1 or KS C 8460 and KS C 8461.

2.4.2.2 Flexible Metal Conduit

Flexible metal conduit shall be UL 1, zinc-coated steel. UL 360 liquid-tight flexible metal conduit shall be used in wet locations.

2.4.2.3 Outlet Boxes for Use with Steel Conduit, Rigid or Flexible

These outlet boxes shall be UL 514A, cast metal with gasket closures.

2.4.2.4 Plastic Duct for Concrete Encased Burial

These ducts shall be PVC conforming to NEMA TC 6 & 8, Type EB or provided as specified in Section 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.4.2.5 Plastic Conduit for Direct Burial

This plastic conduit shall be PVC conforming to NEMA TC 2 (conduit) and NEMA TC 3 (fittings) Type EPC-40 PVC , or provided as specified in Section 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.4.2.6 Frangible Couplings and Adapters

These frangible couplings shall be in accordance with FAA 6850.19 and FAA E-2519. Provide upper section of frangible coupling with one of the following:

a. Unthreaded for slip-fitter connections.

b. 61.1 mm (2-13/32 inch) 16N-1A modified thread for nut and compression ring to secure 50 mm 2 inch EMT.

c. 50 mm (2 inch) 11-1/2-N.P.T. (tapered) with 5.6 mm (7/32 inch) nominal wall thickness to accept rigid conduit coupling.

d. Frangible Couplings for specialized applications as approved.

e. Electrical Metallic Tubing UL 797, where indicated for use with frangible couplings and adapters.

2.4.2.7 Low-Impact-Resistant Towers

Fiberglass reinforced low-impact resistant (LIR) towers shall conform to FAA E-2702 or FAA AC 150/5345-45. Anchor bolts, lowering devices and fixture mounting accessories shall be provided as required by tower manufacturer.

2.4.2.8 Semi-Frangible Supports

Lights supported more than 12 m (40 feet) above the ground shall have a two-element structure, the lower element being a rigid structure and the upper element being a 6.1 m (20 foot) LIR structure in accordance with FAA E-2702.

2.4.3 Wire and Cable

Conductors shall be copper except as otherwise indicated.

2.4.3.1 Conductor Sizes

Conductor size shall conform to American Wire Gage (AWG). Conductor sizes larger than No. 8 AWG shall be stranded. No. 8 AWG and smaller may be solid or stranded unless otherwise indicated.

2.4.3.2 Low Voltage Wire and Cable

UL 854, Type USE, 600 volts shall be used for underground low voltage power cables. UL 83, Type THW, THWN or UL 44, Type XHHW shall be used for secondary series lighting circuits to be installed in pavement.

2.4.3.3 Power Cables for Airfield and Heliports

Power cables shall be rated 5 kV (or 25 kV), 133 percent insulation level, with shield and jacket conforming to UL 1072 (and AEIC CS8) for cross-linked polyethylene or for ethylene-propylene rubber insulated cables.

2.4.3.4 Wire and Cable for Airfield and Heliports

a. Airfield and heliport lighting cable shall be FAA AC 150/5345-7, Type

L-824 for cross-linked polyethylene Type C or Type B 600 or 5000-volt cable. Series airfield and heliport lighting cable shall be unshielded. Type C is recommended for single conductor cable. If soil conditions require a jacketed cable for protection of insulation, It is recommended to use Type B.

b. Cable for pavement slot installation shall be UL 44 Type XHHW, except as indicated otherwise.

c. Counterpoise Wire. Bare stranded copper, annealed or soft drawn with the size as indicated.

d. Control Cable. Multiconductor type FAA AC 150/5345-7, Type A, B, or C for 120 volt AC control, rated 600 volts, and conforming to the following unless indicated otherwise. Conductors shall be color coded. The cable shall have an overall jacket of heavy-duty neoprene or PVC rated for direct burial. FAA AC 150/5345-7, Type A, B or C rubber insulation for cross-linked polyethylene insulation or for ethylene-propylene rubber insulation. For 48 volt DC control, multi-conductor, 300 volts, No. 19 AWG cable shall be in accordance with RUS Bull 345-67.

e. Fused Cable Connectors. Connector shall consist of a line-side receptacle and a load-side plug, each in a molded rubber form and including crimp-on fittings for the cable ends to accommodate a 250-volt cartridge-type fuse with fuse rating as indicated. Connectors in kit form shall be properly sized for the specific cable diameter involved. Completed connection shall be watertight.

f. Cable for sequence flashing trigger circuits shall be RUS Bull 345-67.

2.4.3.5 Cable Tags

Install cable tags for each cable or wire at duct entrances entering or leaving manholes, handholes, and at each terminal within the lighting vault. Cable tags shall be stainless steel, bronze, lead strap, or copper strip, approximately 1.6 mm (1/16 inch) thick or hard plastic 3.2 mm (1/8 inch) thick suitable for immersion in salt water and impervious to petroleum products and shall be of sufficient length for imprinting the legend on one line using raised letters. Cable tags shall be permanently marked or stamped with letters not less than 6.4 mm (1/4 inch) in height as indicated. Two-color laminated plastic is acceptable. Plastic tags shall be dark colored with markings of light color to provide contrast so that identification can be easily read. Fastening material shall be of a type that will not deteriorate when exposed to water with a high saline content and to petroleum products.

2.4.3.6 Concrete Markers for Direct Buried Cable Systems

Concrete markers shall be as specified in Section 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.4.4 Ground Rods

Ground rods shall be sectional copper-clad steel with diameter adequate to permit driving to full length of the rod, but not less than 19.1 mm (3/4 inch) in diameter and not less than 3.048 m (10 feet) long, unless indicated otherwise.

2.4.5 Lightning Arresters

These lightning arresters shall be in accordance with IEEE C62.11, IEEE C62.41.1 and IEEE C62.41.2 as applicable with ratings as indicated.

2.4.6 Surge Protection

Surge protection shall be metal oxide varistors (MOV) in accordance with NEMA LA 1 for power and signal circuits with ratings as recommended by the system manufacturer.

2.4.7 Cable Connectors and Splices

Cable connectors in accordance with FAA AC 150/5345-26, Item L-823 shall be used for connections and splices appropriate for the type of cable. Other types of cable connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. For FAA Type L-824 lighting cable, connectors shall be FAA AC 150/5345-26, Type L-823.

2.4.8 Transformers

2.4.8.1 Encapsulated Isolation Transformers

These transformers shall be FAA AC 150/5345-47, Type L-830. Each transformer shall be provided with rating as shown on the contract drawings.

2.4.8.2 Power Transformers

These transformers shall be in accordance with IEEE C57.12.50 as indicated.

2.4.9 Light Bases

Light bases shall be FAA AC 150/5345-42 Type L-867 or L-868. Steel bases, Class 1, Size A, B, or C shall be provided as indicated or as required to accommodate the fixture or device installed thereon if diameter is not shown. Base plates, cover plates, and adapter plates shall be provided to accommodate various sizes of fixtures. Bolts shall be stainless steel.

2.4.10 Sealant for Fixtures and Wires in Drilled Holes or Saw Kerfs

The sealant shall be in accordance with FAA AC 150/5370-10, Type P-606. Use FAA AC 150/5370-10, Type P-606 sealant for use in asphaltic concrete (AC) or Portland cement concrete (PCC) pavement compatible with AC pavement and having a minimum elongation of 50 percent. Formulations of Type P-606 which are compatible with PCC pavement only are prohibited.

2.4.11 Constant Current Regulator

The regulator shall be FAA AC 150/5345-10, Type L-829 with monitoring system and with ratings as indicated. Regulators shall operate on 60 Hz, have internal primary switch included, have input voltage of 208 (or 480) and be controlled by 120-volt external control voltage. Three or Five brightness steps shall be provided. Monitors shall be provided as indicated.

2.4.12 Lamps and Filters

Lamps shall be of size and type indicated, or as required by fixture manufacturer for each lighting fixture required under this contract. Filters shall be of colors as indicated and conforming to the specification for the light concerned or to the standard referenced.

2.4.13 Sump Pumps for Manholes and Vaults

Sump pumps shall be submersible type with a sufficient capacity. The motor shall include automatic thermal overload protection. Each pump shall have an internal magnetic float switch, stainless steel shaft, bronze impeller, and cast iron motor housing and volute. The cable shall be continuous and of a waterproof type with watertight plug of sufficient length to include slack and allow connection to receptacle shown.

2.4.14 Circuit Breakers and High-Voltage Switches

Circuit breakers and high-voltage switches shall be UL 489 type or approved by UL 489. Switchgear for use in manholes and underground vaults shall be subway type. Hermetically sealed cutouts shall be provided with expansion chambers for full rating. Cutout shall be mounted on galvanized steel junction boxes with bolted-on covers, unless indicated otherwise.

2.4.15 Transformer, Substations and Switchgear

The transformer substations and switchgear shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.16 Emergency Generator and Automatic Transfer Switch System

The automatic transfer switch shall be in accordance with Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH and as required by the contract drawings or contracting documents. The emergency generator shall be in accordance with section 26 32 15.00 10 DIESEL-GENERATOR SET STATIONARY 100-2500 kW, WITH AUXILIARIES in UFGS and Section 26 32 14.00 10, DIESEL-GENERATOR SET, STATIONARY 15-300 kW, STANDBY APPLICATIONS and as required by the contract drawings or contracting documents.

2.4.17 Circuit Selector Cabinet

The circuit selector cabinet shall be FAA AC 150/5345-5, Type L-847, for one, two, three or four circuit control as indicated, Class A(indoor) or B (outdoor), Rating 1 (for 6.6 amperes) or 2 (for 20 amperes).

2.4.18 Pilot Relay Panel

The pilot relay panel shall be NEMA 250, NEMA ICS 2, and NEMA PB 1 for 120-volt control systems; and FAA AC 150/5345-13, Type L-841, for 48-V dc control systems.

2.4.19 Control Panel

The panel shall be FAA AC 150/5345-3, Type L-821 Type II, Class F,S or W, Style 2 or 3. Quantity and color of lenses shall conform to FAA AC 150/5345-3 and shall correspond to the actual circuits indicated.

2.4.20 Lighting Fixtures

Provide lighting fixtures for the airfield and heliport lighting as shown in the contract drawings or as required in other contract documents.

2.4.21 Painting

As specified in Section 09 90 00 PAINTS AND COATINGS and Section 32 17 24.00 10, PAVEMENT MARKINGS.

2.5 AIRFIELD AND HELIPORT MARKINGS

The airfield and heliport markings shall be installed as shown on the contract drawings.

2.6 BEACON

The rotating beacons for airfield and heliport beacons are omnidirectional and color coded and are provided by rotating the beams in sequence to provide the color and intensity. For military facilities the beacon has a double-peaked white beam. The beacon flashes shall be visible through 360 degrees.

2.6.1 Airfield Rotating Beacon

The rotating beacon for fixed wing aircraft shall be FAA AC 150/5345-12, Type L-802A, Class 1 or 2. A duplex type beacon with alternating green and white beams shall be provided. Beacons used on military airfields shall have a double-peaked white beam. Cabinet shall be provided with a NEMA ICS 6 type 3R enclosure of zinc-coated steel.

2.6.2 Heliport Beacon

The heliport rotating beacon, shall be FAA AC 150/5345-12, Type L-801H, Class 2. Except for military facilities the white beam shall be a double-peaked white flash. The beacon shall flash the three color sequence 10 to 15 times per minutes. The colors are white, green, and yellow for a heliport. The effective intensity of the white flash shall be not less than 25,000 candelas for vertical angles between 2 and 8 degrees and not less than 12,500 candelas between 0 and 10 degrees.

2.6.3 Airfield Identification/Code Beacon

If an identification or code beacon is required, the fixture shall be in accordance with FAA AC 150/5345-43, Type L-866 with green filters and code flashing device. The beacon flashes shall be visible through 360 degrees. The effective intensity of the green flash shall be not less than 2,000 candelas. The code shall be as indicated on the contract drawings and shall flash 6 to 8 codes per minute.

2.7 WIND DIRECTION INDICATOR

The wind direction indicator shall be an FAA AC 150/5345-27, Type L-806, low mass supporting structure or L-807, rigid supporting structure, Style I-lighted or II-unlighted, Size 304.8 to 2438 mm(1 to 8 feet) OR 609 to 3658 mm(2 to 12 feet). The wind cones shall be of the size and color as indicated.

2.8 OBSTRUCTION LIGHTING AND MARKING

Obstructions on or near the airfield, heliport shall be marked and/or lighted as shown on the contract drawings. Obstruction marker lights shall emit aviation red steady burning light as required. The light fixtures, shall be multiple-socket assembly FAA AC 150/5345-43, Type L-810. For multiple flashing lights on a circuit, the lights shall flash in unison. Obstruction marker lights shall be single- or double-unit type as shown in the contract drawings. The obstruction lights shall be energized from series circuits as shown on the contract drawings or other contract documents.

2.9 HIGH-INTENSITY APPROACH LIGHTING SYSTEMS

These lights shall be as indicated.

2.9.1 Elevated High-Intensity Fixtures Except Flashing Units

The elevated approach light fixtures shall be FAA E-982 frangible mounted lights with PAR-56 200 W, 300 W or 500 W lamps as specified, and with/without aviation red and/or with aviation green filters as indicated. Elevated bidirectional threshold lights shall be FAA AC 150/5345-46, Type L-862 with aviation green filters on the approach side and aviation red filters on the runway side. The side row barrettes shall emit aviation red lights.

2.9.2 Sequence Flashing Lights (SFL) System

The SFL system shall be FAA E-2159 and/or FAA AC 150/5345-51, Type L-849 or FAA E-2628 lights provided as an integrated part of the approach system. The SFL system shall include up to the 21 elevated fixtures, the individual power supplies, master timer and power supply, remote control and monitor, support structures, and interconnecting wiring. The SFL shall flash twice per second in sequence towards the runway threshold.

2.9.3 Semiflush, High-Intensity Approach Lights

The approach lights in the overrun area, inner section of threshold bar, and paved areas with traffic, shall be semiflush, high-intensity, base-mounted lights as shown. These semiflush approach high-intensity fixtures shall be FAA AC 150/5345-46, Type L-850D (for bidirectional), Type L-850E (for unidirectional) lights with lamps and filters as shown.

2.10 MEDIUM-INTENSITY APPROACH LIGHTING SYSTEMS

The medium-intensity approach lights shall be as indicated.

2.10.1 Elevated, Medium-Intensity, Steady-Burning Fixtures

The medium-intensity, elevated, steady-burning approach lights, shall be FAA E-2980 PAR 38 lampholders with 150 watt, PAR-38 spotlight lamps frangibly mounted on light bases and/or low-impact-resistant supports , frangible supports.

2.10.2 Sequence Flashing Lights (SFL) for Medium Intensity Lights

These elevated SFL fixtures (RAIL) shall meet the requirements of FAA E-2159 or FAA AC 150/5345-51, Type L-849 with several lights shall be as indicated on the contract drawings as an integrated part of the approach system. The SFL system shall include the fixtures, the individual power supplies, master timer and power supply, remote control and monitor support structures, and interconnecting wiring. The SFL shall flash twice per second in sequence towards the runway threshold.

2.11 RUNWAY ALIGNMENT INDICATOR LIGHTS (RAIL)

The RAIL fixtures shall meet the requirements of FAA E-2159 or FAA AC 150/5345-51, Type L-849 with several lights and shall include the individual power supplies the master timer and power supply, remote control, support structures, and interconnecting wiring.

2.12 OMNIDIRECTIONAL APPROACH LIGHT SYSTEM (ODALS)

The ODALS fixtures shall meet the requirements of FAA AC 150/5345-51, Type L-859 Style F. The ODALS shall include the several fixtures, the individual power supplies, the master timer and power supply, remote control, support structures and interconnecting wiring. The ODALS shall flash twice per second in sequence towards the runway threshold.

2.13 RUNWAY END IDENTIFIER LIGHTS (REIL)

The REIL fixtures shall meet the requirements of FAA AC 150/5345-51, Type L-849, Style A, B or E. The REIL shall include the master and slave fixture, the power supply, remote control, frangible mounts, and interconnecting wiring. The REIL units shall flash in unison twice per second.

2.14 RUNWAY LIGHTING SYSTEM

Runway lights include runway edge lights, runway threshold lights, runway centerline lights, runway touchdown zone lights, runway distance and arresting gear markers, mounting structures, controls, and the associated equipment and interconnecting wiring to provide complete systems as indicated and specified herein. In-pavement light fixtures shall be able to withstand a minimum static single wheel load of 22,680 kg (50,000 pounds).

2.14.1 Runway Edge Lights

The runway edge light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-862, elevated high-intensity and Type L-850C, semiflush, high-intensity white lights.

2.14.2 Runway Threshold and End Lights

The threshold lights shall use aviation green filter and the end lights shall use aviation red filters. These lights shall be combined in a single bidirectional fixture with the appropriate color filters if so indicated on the contract drawings. The runway threshold/end light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-852E(semiflush, medium-intensity, omnidirectional), Type L-850D(semiflush, high-intensity, bidirectional), or Type L-850C(semiflush, high-intensity, unidirectional) airfield and heliport lights as indicated.

2.14.3 Runway Centerline Lights, Tail Hook Operations

The fixtures shall be similar to FAA AC 150/5345-46, Type L-852, and identified as Class N (Navy). The fixtures are available from Crouse Hinds Company, Cooper Industries. The fixtures shall be unidirectional, narrow beam, Type V, VI, VII or VIII, with shorting device for failed lamp, modified to resist damage from aircraft tail hooks. The stainless steel top assembly shall have a Rockwell hardness of C40 plus or minus 5. Height of fixture shall be 12.7 mm(1/2 inch) above pavement in lieu of 9.5 mm(3/8 inch). Optical assembly shall be secured with 410 or 416 stainless steel bolts.

2.14.4 Standard Duty Centerline Lights

The fixtures shall be FAA AC 150/5345-46, Type L-850A, Class 1 (for insetting directly into pavement), Class 2 (for installation on mounting bases). Filters shall be provided as indicated and conforming to requirements of fixture specifications.

2.14.5 Runway Touchdown Zone Lights

The fixtures shall be FAA AC 150/5345-46, Type L-850B.

2.14.6 Runway Distance Markers

Runway distance markers shall conform to FAA AC 150/5345-44, Type L-858B, Size 4, Style 3 with white or yellow numerals on a black background. Markers shall be provided, to withstand a static wind load of 1.9 kPa (0.28 psi), and suitable for connection to the secondary of the isolation transformers specified. Internally illuminated markers shall be provided with illumination of the face not less than 50 percent of that at rated current when the series lighting circuit is operated at the lowest brightness step. Marker housing shall be fiber reinforced epoxy, with information faces of high-impact acrylic or ultraviolet stabilized polycarbonate. The power supply and lamps shall be Style 3, as indicated.

2.14.7 Arresting Gear Markers

The arresting gear markers shall be the same as Runway Distance Markers, except markers shall have a 990.6 mm (3.25 foot) translucent yellow circle in place of numerals as specified above.

2.15 TAXIWAY LIGHTING SYSTEMS

Taxiway lighting systems shall include edge lights, centerline lights, guidance signs, and hold position lights and signs. These systems shall also include the associated equipment, power supplies and controls, mounting devices, and interconnecting wiring to provide complete systems as specified.

2.15.1 Taxiway Edge Lights

Taxiway edge light shall emit aviation blue light provided by filters or globes for both airfields and heliports. The edge lights shall meet the requirements of FAA AC 150/5345-46, Type L-861, elevated, or Type L-852E, semiflush lights.

2.15.2 Taxiway Centerline Lights

Taxiway centerline lights shall be semiflush fixtures using filters to provide aviation green light. These centerline light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-852A on straight sections or Type L-852B on curved sections, as indicated.

2.15.3 Taxiway Guidance Signs

The taxiway guidance signs shall meet the requirements of FAA AC 150/5345-44, Type L-858Y for information and Type L-858R for mandatory signs. The size and information on the signs shall be as shown on contract drawings. The power supply to connect to series circuits shall be as approved by the manufacturer.

2.15.4 Hold Position Lights and Signs

The hold positions shall be marked by painted lines and/or signs as specified or indicated on the contract drawings. The lights shall meet the requirements of FAA AC 150/5345-46, Type L-852A, semiflush, unidirectional, with aviation yellow filter toward the taxiway approach to the runway. In some confusing locations FAA AC 150/5345-46, Type L-804, elevated flashing lights may be required. Hold position signs shall meet the requirements of FAA AC 150/5345-44, Type L-858R, with the size and information as indicated.

2.16 HELIPAD LIGHTING SYSTEMS

2.16.1 General

Helipad lighting, when required, shall be in accordance with Section 26 54 21.00 10 HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS in Unified Facilities Guide Specifications(UFGS). Where helipad lighting interfaces with airfield and heliport lighting systems, the helipad lighting as required shall be in accordance with Section 26 54 21.00 10 HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS in Unified Facilities Guide Specifications(UFGS).

2.16.2 Hoverlane Lights

The hoverlane lights shall be alternating aviation green and aviation yellow lights along the centerline of the hoverlane path. The fixtures shall be FAA AC 150/5345-46, Type L-861, for elevated lights with alternating yellow and green globes as required or indicated on the contract drawings. These lights shall be frangibly mounted on stakes or light bases. For hoverlanes across paved areas, the fixtures shall be FAA AC 150/5345-46, Type L-852E mounted on FAA AC 150/5345-42, Type L858 or L-857 light bases. The hoverlane lights shall be energized from a 6.6 ampere series circuit through isolation transformers or 120/240-volt multiple circuit power source as indicated on the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-1.

2.17 EXPLOSION-PROOF FIXTURES FOR HAZARDOUS LOCATIONS

Fixtures to be installed in explosive hazardous locations shall meet the requirements of and be listed by UL Electrical Constructn or FM APP GUIDE as defined in NFPA 70 for the hazard and application. The explosion-proof fixtures are located as indicated or otherwise specified herein.

2.18 GLIDE SLOPE INDICATOR

The glide slope indicator for airfields shall be the Precision Approach Slope Indicator (PAPI). For the heliports the glide slope indicator unit shall be the PAPI or the CHAPI as indicated.

2.18.1 PAPI

The light units for the PAPI shall meet the requirements of FAA AC 150/5345-28, Type L-880, or FAA E-2756. The system consists of four light units.

2.18.2 CHAPI

The light units for the CHAPI systems for heliport glide slope indicators, if required, shall consist of two units which meet the basic requirements of FAA AC 150/5345-28, Type L-880, except the on-glide-slope indication has been replaced by a two degree wide green lens.

2.19 LIMIT LIGHTS

The fixtures for limit lights shall be FAA AC 150/5345-46, Type L-861 with red globes and 45-watt lamps. These lights shall be frangibly mounted on steel stakes or light bases if in paved areas.

2.20 FACTORY COATINGS

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finish shall be provided with corrosion-resistant finishes which shall withstand 200-hour test for noncorrosive environment or 500-hour test for corrosive environment of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with zinc rich paint conforming to SSPC Paint 20 in accordance with ASTM A780/A780M.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 GENERAL INSTALLATION REQUIREMENTS

Circuits installed underground shall conform to the requirements of Section 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND, except as required herein. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 31 00 00 EARTHWORK. Concrete work shall conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 CABLES, GENERAL REQUIREMENTS

The type of installation, size and number of cables shall be as indicated. Conductors larger than No. 8 AWG shall be stranded. Loads shall be divided as evenly as practicable on the various phases of the system. Furnish manufacturer's written recommendations for each type of splice and medium-voltage cable joint and termination, and for fireproofing application methods, approved before any work is done. Medium-voltage cable joints and terminations shall be the standard product of a manufacturer and shall be either of the factory preformed type or of the kit type containing tapes and other required parts. Medium-voltage cable joints shall be made by qualified cable splicers. Compounds and tapes shall be electrical grade suitable for the cable insulation provided and shall use design materials and techniques recommended by the manufacturer. Maximum length of cable pull and cable pulling tensions shall not exceed the cable manufacturer's recommendations.

3.3.1 Duct Line Installation

Install cables in duct lines where indicated. Cable splices in low-voltage cables shall be made in manholes and handholes only, except as otherwise noted. Cable joints in medium-voltage cables shall be made in manholes only. Neutral and ground conductors shall be installed in the same duct with their associated phase conductors. Counterpoise cable shall be installed in a separate duct or direct-burial not less than 150 mm (6 inches) above the uppermost duct containing electrical cable. Electrical metallic tubing shall not be installed underground or enclosed in concrete.

3.3.2 Direct-Burial Installation

Cables shall be buried directly in the earth as indicated. Minimum cover from the top of a cable to finished grade shall be 600 mm (24 inches) for low-voltage cables, 950 mm (36 inches) for medium-voltage cables but not less than the depth of the frost line. Counterpoise cable shall be not less than 150 mm (6 inches) above the uppermost electrical cable but not less than the depth of the frost line.

3.3.2.1 Trenching

Trenches for direct-burial cables shall be excavated to depths required to provide the minimum necessary cable cover. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where bottoms of trenches comprise materials other than sand or stone-free earth, 75 mm (3 inch) layers of sand or stone-free earth shall be laid first and compacted to approximate densities of surrounding firm soil.

3.3.2.2 Cable Installation

Cables shall be unreeled along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position will not be permitted, except as required to pull cables through conduits under paving or railroad tracks. Where cables cross or are installed in layers at different depths, a separation of at least 75 mm (3 inches) vertically and 50 mm (2 inches) horizontally shall be provided, unless each cable circuit is protected by a nonmetallic conduit sleeve at the crossing. Where single-conductor cable is installed for three-phase circuits, all three phases and the neutral shall be installed in the same sleeve. Bend radius of any cable shall be not less than 12 times the diameter of the cable. In no case shall cables be left under longitudinal tension. The first 150 mm(6 inch) layer of backfill shall be of sand or stone-free earth. A 0.127 mm (5 mil), brightly colored plastic tape not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers, or other approved dig-in warning indication, shall be placed approximately 300 mm (12 inches) below finished grade levels of trenches. Selected backfill of sand or stone-free earth shall be provided to a minimum depth of 75 mm (3 inches) above cables.

3.3.2.3 Other Requirements

Where direct-burial cables cross under roads or other paving exceeding 1.5 m (5 feet) in width, such cables shall be installed in concrete-encased ducts. Where direct-burial cables cross under railroad tracks, such cables shall be installed in reinforced concrete encased ducts. Ducts shall extend at least 300 mm (1 foot) beyond each edge of any paving and at least 1.5 m (5 feet) beyond each side of any railroad tracks. Cables may be pulled into conduit from a fixed reel where suitable rollers are provided in the trench. Direct-burial cables shall be centered in duct entrances. A suitable waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by suitable predrilling. Where cuts are made in any paving, the paving and sub-base shall be restored to their original condition.

3.3.2.4 Medium-Voltage Cable Joints or Low-Voltage Cable Splices

Cable joints or splices in direct-burial cables are neither permitted in runs of 300 m (1000 feet) or less, nor at intervals of less than 300 m (1000 feet) in longer runs, except as required for taps. Locations of cable joints or splices in shorter intervals, where required to avoid obstructions or damage to cables, shall be approved. Cable joints or splices shall be installed in cable boxes, except that medium-voltage separable connectors or low-voltage sealed insulated connectors do not require cable boxes.

3.3.2.5 Surface Markers

Locate markers near the ends of cable runs, at each cable joint or splice, at approximately every 150 m (500 feet) along cable runs, and at changes in direction of cable runs. In addition to markers, a 0.127 mm (5 mil), brightly colored plastic tape not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers, or other approved dig-in warning indication, shall be placed approximately 300 mm (12 inches) below finished grade levels of trenches.

3.3.3 Connection to Buildings

Cables shall be extended into the various buildings as indicated, and shall be properly connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 1.5 m (5 feet) outside of a building and 600 mm (2 feet) below finished grade as specified and provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.4 MEDIUM-VOLTAGE CABLES

Medium-voltage cables shall be suitable for a rated circuit voltage as indicated. Other parts of the cable system such as joints and terminations shall have ratings not less than the rating of the cables on which they are installed. Separable insulated connectors shall have nominal voltage ratings coordinated to associated apparatus ratings rather than cable ratings when used to connect cable to apparatus. Cables shall be provided with 133 percent insulation level. 28 kV and 35 kV insulation thicknesses shall be in accordance with either AEIC CS8 as applicable. Neutral conductors of grounded neutral systems shall be of the same insulation material as phase conductors, except that a 600-volt insulation rating is acceptable.

3.4.1 Cable Joints

Apply shields as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of preformed joints. Shields shall be grounded at each joint.

3.4.1.1 Types

Separable insulated connectors of suitable construction or standard splice kits shall be used for single-conductor and two-conductor cables. The connectors shall be of FAA AC 150/5345-26 type. Cable joints for which acceptable separable connector kits are not available may use factory preformed, vulcanized taped joint or resin pressure-filled over-case taped splices if approved.

3.4.1.2 Requirements

Cable joints shall provide insulation and jacket equivalent to that of the associated cable. Lead sleeves shall be provided for lead-covered cables. Armored cable joints shall be enclosed in compound-filled, cast-iron or alloy, splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

3.4.2 Terminations

Terminations shall be IEEE 48, Class 1 or Class 2, of the molded elastomer, wet-process porcelain, prestretched elastomer, heat-shrinkable elastomer, or taped type. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations shall be of the outdoor type, except that where installed inside outdoor equipment housings which are sealed against normal infiltration of moisture and outside air, indoor, Class 2 terminations are acceptable. Class 3 terminations are not acceptable. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, and armor.

3.4.2.1 Factory Preformed Type

Molded elastomer, wet-process porcelain, prestretched, and heat-shrinkable terminations shall utilize factory preformed components to the maximum extent practicable rather than tape build-up. Terminations shall have basic impulse levels as required for the system voltage level. Leakage distances shall pass the wet withstand voltage test required by IEEE 48 for the next higher BIL level.

3.4.2.2 Taped Terminations

Taped terminations shall use standard termination kits providing suitable terminal connectors, field-fabricated stress cones, and rain hoods. Terminations shall be at least 318 mm (12-1/2 inches) for 5 kv cable, 508 mm (20 inches) for 15 kv cable, 635 mm (25 inches) for 25 kv cable, 889 mm (35 inches) for 28 or 35 kv cable, 1200 mm (46 inches) for 28 or 35 kv in contaminated areas cable, long from the end of the tapered cable jacket to the start of the terminal connector, or not less than the kit manufacturer's recommendations, whichever is greater.

3.5 LOW-VOLTAGE CABLES

Cable shall be rated 600 volts, except that secondaries of isolation transformer to in-pavement lights installed in pavement saw kerf and 48 volt DC control cables may be 300 volts. Other parts of cable systems such as splices and terminations shall be rated at not less than 600 volts. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. Splices in wires No. 8 AWG single conductor cable shall be made with FAA AC 150/5345-26 Type L-823 connectors or noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.
Do not apply tape or heat shrinkable tubing over secondary connectors of isolation transformers at the frangible couplings.

3.6 DUCT LINES

Duct lines shall be concrete-encased or non-concrete-encased as indicated, schedule 80, PVC

3.6.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 100 mm per 30 m (4 inches per 100 feet). Depending on the contour of the finished grade, the high point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Manufactured 90 degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) for ducts of less than 78 mm (3 inches) diameter, and 900 mm (36 inches) for ducts 78 mm (3 inches) or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m (25 feet) shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends as required, but the maximum curve shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells when duct lines terminate in manholes or handholes. Duct line markers shall be provided as indicated at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In lieu of markers, a 0.127 mm (5 mil) brightly colored plastic tape not less than 76.2 mm (3 inches) in width and suitably inscribed at not more than 3.0 m (10 feet) on centers with a continuous metallic backing and a corrosion-resistant 0.025 mm (1 mil) metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm (12 inches) below finished grade levels of such lines.

3.6.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. After a duct line is completed, a standard flexible mandrel shall be used for cleaning followed by a brush with stiff bristles. Mandrels shall be at least 300 mm (12 inches) long and shall have diameters 6.2 mm (1/4 inch) less than the inside diameter of the duct being cleaned. Pneumatic rodding may be used to draw in lead wires. A coupling recommended by the duct manufacturer shall be used when an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Concrete Encasement

Each single duct shall be completely encased in concrete with a minimum of 75 mm (3 inches) of concrete around each duct, except that only 50 mm (2 inches) of concrete are required between adjacent electric power or adjacent communication ducts, and 100 mm (4 inches) of concrete shall be provided between adjacent electric power and communication ducts. Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. At any point, tops of concrete encasements shall be not less than 450 mm (18 inches) below finished grade or paving. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not further apart than 1.2 m (4 feet) on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 150 mm (6 inches) vertically.

3.6.4 Non-encased Direct-Burial

Top of duct lines shall be below frost line but not less than 1200 mm (48 inches) below finished grade. Ducts shall be buried below frost line but in the earth and shall be installed with a minimum of 77 mm (3 inches) of earth around each duct, except that between adjacent electric power and communication ducts, 300 mm (12 inches) of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand or stone-free earth, 75 mm (3 inch) layers of sand or stone-free earth shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts in direct-contact tiered fashion. Joints in adjacent tiers of duct shall be vertically staggered at least 150 mm (6 inches). The first 100 mm (4 inch) layer of backfill cover shall be sand or stone-free earth compacted as previously specified. Duct banks may be held in alignment with earth. However, high-tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling. Selected earth at duct banks shall be thoroughly tamped in 100 to 150 mm (4 to 6 inch) layers.

3.6.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved. In the absence of specific recommendations, various types of duct joint couplings shall be made watertight as specified.

3.6.5.1 Bituminized-Fiber Ducts

To ensure a watertight joint, tapered ends or joints of the same material as the ducts shall be swabbed with bituminous or joint-sealing compound before couplings are applied. Plastic or nonmetallic couplings shall be tightly driven onto unswabbed ducts. Due to the brittleness of plastic couplings at low temperatures, such couplings shall not be installed when temperatures are below -18 degrees C (0 degrees F). Couplings shall be warmed in hot water or by another approved method when installed at temperatures below 0 degrees C (32 degrees F).

3.6.5.2 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick one-quarter-turn twist to set the joint tightly.

3.7 MANHOLES AND HANDHOLES

The manholes and handholes shall be as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Note that airfield type manholes, vaults, handholes, and their associated frames and covers require a design for a maximum single wheel load of 22,680 kg (50,000 pounds) or dual wheel load of 40,820 kg (90,000 pounds). Use steel conforming to ASTM A36/A36M, for covers to airfield manholes, vaults, and handholes. Use ductile iron for frames conforming to ASTM A536, grade 65-45-12..

3.8 WELDING

Perform the welding of supports and metallic ducts and welding or brazing of electrical connections by using qualified welders.

3.9 CABLE MARKERS

Provide cable markers or tags for each cable at duct entrances entering or leaving manholes or handholes and at each termination within the lighting vault. Cables in each manhole or handhole shall have not less than two tags per cable, one near each duct entrance hole. Immediately after cable installation, tags shall be permanently attached to cables and wires so that they cannot be accidentally detached.

3.10 FRANGIBLE REQUIREMENTS

Install frangible supports, couplings, and adapters as indicated or specified. At the 300 m (1000 foot) cross bar and beyond, approach lights shall be mounted up to 1.8 m (6 feet) above concrete foundation on threaded frangible couplings and 53 mm (2 inch) electrical metallic tubing (EMT). For mounting heights greater than 1.8 m (6 feet), approach lights shall be mounted on low-impact resistant frangible towers as indicated.

3.11 ELEVATED AIRFIELD AND HELIPORT LIGHTS

Elevated lights shall be frangibly mounted, not to exceed 350 mm (14 inches) in height except where higher mounting is permitted in snow accumulation areas. Equipment exceeding 350 mm (14 inches) in height shall be frangibly mounted as indicated.

3.12 SEMIFLUSH AIRFIELD AND HELIPORT LIGHTS

Remove water, debris, and other foreign substances prior to installing semiflush light base and light. Use positioning jigs to hold the light bases and/or lights to ensure correct orientation and leveling until the concrete, adhesive, or sealant can provide permanent support.

3.13 ENCLOSURES IN SAW KERFS AND DRILLED HOLES

3.13.1 Holes for Light Fixtures

Holes shall be bored in existing pavement to the dimensions indicated with a diamond-edged bit to provide a smooth, straight cut. Bottom of hole shall be flat or slightly concave, except that an area at least 25 mm (1 inch) wide around the perimeter shall be flat. Surfaces deeper than the prescribed depth shall be filled with sealant to the level of the flat area and allowed to cure before further placement.

3.13.2 Holes for Transformer Enclosures

Holes shall be drilled or excavated through concrete pavement and loose material removed. Hole shall be filled with concrete to depth indicated. A minimum of 75 mm (3 inches) of concrete shall be provided at bottom of hole.

3.13.3 Saw Kerfs and Splice Chambers

Saw kerfs and splice chambers shall be cut in pavements where indicated. Saw cuts shall be in straight lines with vertical sides. Width and depth of saw cuts shall be adequate for the required number of wires. Saw kerfs shall have the vertical edges chamfered at intersections. Where a saw kerf crosses a construction joint, the depth shall be increased sufficiently to allow for slack wire under the joint. The wire shall be enclosed in flexible tubing which extends not less than 600 mm (2 feet) each side of the joint.

3.13.4 Sandblasting

Saw kerfs, grooves, and holes shall be sandblasted to remove foreign or loose material. Sandblasting shall use approved equipment maintained in good working order. Sand for blasting shall be proper size and quality to perform the work. Nozzles for sandblasting shall be of the proper size in relation to the groove or holes to be cleaned. Nozzles enlarged by wear shall be replaced as necessary. Sandblast air pressure shall be not less than 621 kPa (90 psi).

3.13.5 Cleaning

Immediately prior to installation of wire or light fixtures, saw kerfs and holes shall be flushed with a high velocity water jet or steam, and then cleaned and dried with a high velocity air jet to remove dirt, water, and foreign material.

3.14 FIXTURES AND WIRES INSTALLATION

3.14.1 General

Sides and bottom of each light base shall be sandblasted immediately prior to installation. Inside faces of bored hole and bottom and sides of light base shall be covered with a coating of sealant that will completely fill the void between concrete and base. A jig or holding device shall be used when installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Light fixture shall be oriented with the light beams parallel to the runway or taxiway centerline and facing in the required direction. Outermost edge of fixture shall be level with the surrounding pavement. Surplus sealant or flexible embedding material shall be removed. The holding device shall remain in place until sealant has reached its initial set. Fixture lead wires shall be properly arranged with respect to their connecting position. The wireway entrance into the light recess shall be blocked to retain the sealant material during curing.

3.14.2 Installation of Circuit Wires in Pavement

Place wires in saw kerfs and anchor them at bottom by means of rubber or plastic wedges or noncorrosive metal clips placed every 600 or 900 mm (2 or 3 feet) or as often as necessary to hold the wire down. Wires crossing existing joints shall be encased in a 600 mm (24 inch) length of flexible tubing of polyethylene material conforming to ASTM D1248, Type II or Type III, to break the bond between the wires and the sealing material. Flexible tubing shall be centered on the joint and of sufficient size to accommodate the wires to allow for movement of the wires as the joint opens and closes. Ends of tubing shall be wrapped with tape to prevent entrance of sealing materials. The adjacent joint area shall be packed temporarily with roving material, such as hemp, jute, cotton or flax, to prevent sealing material from flowing into the open joint. Sealing materials shall be carefully mixed and applied in accordance with the manufacturer's instructions and at the recommended temperature. Surplus or spilled material shall be removed.

3.15 SPLICES FOR AIRFIELD AND HELIPORT LIGHTING CABLE

3.15.1 Connectors

Kit type connectors shall be used to splice 5 kV single-conductor series lighting cables. During installation and prior to covering with earth, mating surfaces of connectors shall be covered until connected and clean when plugged together. At joint where connectors come together, heat shrinkable tubing shall be installed with waterproof sealant with two half-lapped layers of tape over the entire joint. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.15.2 Splicing Fixtures to the Wires in Pavement Saw Kerfs

Splices shall have preinsulated watertight connector sleeves crimped with a tool that requires a complete crimp before tool can be removed. Splice shall be taped with plastic insulating tape.

3.16 GROUNDING SYSTEMS

3.16.1 Counterpoise Installation

Counterpoise wire shall be laid for entire length of circuits supplying airfield lighting. Wire shall be in one piece, except where distance exceeds the length usually supplied. Counterpoise shall be installed on top of the envelope of concrete-encased duct and approximately 150 mm (6 inches) above direct burial cables and duct lines. Where trenches or duct lines intersect, counterpoise wires shall be electrically interconnected by exothermic welding or brazing. Counterpoise to earth ground shall be connected at every 600 m (2,000 feet) of cable run, at lighting vault, and at feeder connection to light circuit by means of ground rods as specified. Counterpoise shall be installed in a separate duct under roads, railroads, and paved areas above the highest duct containing electrical or communications circuits. Where duct lines run parallel to the edge of a runway, taxiway or apron, the counterpoise shall be located half the distance between the duct and the active pavement edge as shown on the drawings.

3.16.2 Fixture Grounding

Each fixture or group of adjacent fixtures shall be grounded by a grounding circuit separate from the counterpoise system unless required otherwise or by driven ground rods if permitted. Fixtures, steel light bases or grounding bushings on steel conduits shall be connected to an independent ground rod by a No. 6 AWG bare stranded copper wire. Semiflush fixtures for direct mounting in pavement need not be grounded. Copper wire shall be connected to ground rods by exothermic weld or brazing.

3.17 MARKING AND LIGHTING OF AIRWAY OBSTRUCTIONS

Towers, poles, smokestacks, buildings of certain shapes and sizes, and other obstructions shall be marked and lighted in accordance with FAA AC 70/7460-1 and as indicated in or required otherwise.

3.17.1 Painting of Airway Obstructions

Patterns and colors to mark obstructions shall conform to FAA AC 70/7460-1 and shall be as indicated.

3.17.2 Obstruction Marker Lights

Obstruction marker lights shall be installed on radio towers, elevated water tanks, smokestacks, buildings, and similar structures with 25 mm (1 inch)zinc-coated rigid steel conduit stems using standard tees and elbows, except that lowering devices, when required, shall be installed in accordance with equipment manufacturer's recommendations.

3.18 AIRFIELD ROTATING LIGHT BEACON

Install beacon in accordance with the manufacturer's instructions and other contract requirements including cleaning, lubrication, adjustment, and other special instructions. Provide foundations and supports as indicated.

3.18.1 Beam Adjustment

Adjust beam during hours of darkness. Aim beam to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.18.2 Power Supply and Wiring

Install panelboard at top of structure to provide separately protected circuits for beacon lamps, heaters, motor, and obstruction lights. Install cabinet on side of platform opposite ladder. Conduit riser shall be installed on tower in a corner angle and not near ladder.

3.19 HELIPORT LIGHT BEACON

Install beacon in accordance with the manufacturer's instructions and other contract requirements including cleaning, lubrication, and adjustment. Provide foundations and supports as indicated.

3.19.1 Beam Adjustment

Adjust beam during hours of darkness. Aim beam to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.19.2 Power Supply and Wiring

Install panelboard at top of structure to provide separately protected circuits for beacon lamps, heaters, motor, and obstruction lights. Cabinet shall be installed on side of platform opposite ladder. Install conduit riser on tower in a corner angle and shall not be located near ladder. The terminal cabinet shall be in accordance with NEMA ICS 6 Type 3R or as required otherwise.

3.20 WIND DIRECTION INDICATORS

Include in the installation a black circle constructed on the ground with center at center of the base. Construct the circle using an emulsified asphalt-sand mixture or of a cut-back asphalt-sand mixture not less than 125 mm (5 inches) in thickness. Asphalt-sand mixture shall contain not less than 6 percent bitumen. Sand shall be well-graded with not more than 10 percent material which will pass through a No. 200 mesh sieve. Asphalt-sand mixture shall be compacted thoroughly and sloped for drainage from center to outer rim from one side to the other. Wind cone direction indicator shall be guyed as indicated. The wind cone illumination lights and obstruction lights shall be energized from series or multiple circuits as shown by the contract drawings or as required otherwise.

3.21 ISOLATION TRANSFORMERS

Transformer lead connections shall conform to FAA AC 150/5345-26. Transformer secondary connectors shall plug directly into a mating connector on the transformer secondary leads. During installation, mating surfaces of connectors shall be covered until connected and clean when plugged together. At joint where connectors come together, heat shrinkable tubing shall be installed with waterproof sealant or with two half-lapped layers of tape over the entire joint. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.22 RUNWAY AND TAXIWAY LIGHTING SYSTEMS

3.22.1 Runway and Taxiway Edge Lights

Edge lights shall be elevated type lights except in paved areas where semiflush lights are required. Threshold and runway end lights shall be semiflush type as indicated on the contract drawings. Elevated lights shall be frangibly mounted and each light supplied power through an isolation transformer. The taxiway lights shall be omnidirectional and only require leveling. The runway lights require leveling and alignment of the beams for the correct toe-in of the beams.

3.22.2 Runway and Taxiway Centerline Lights

These lights may be mounted on light bases or in drilled holes as indicated on contract drawings. A transformer shall be provided for each group of four 45-watt or three 65-watt centerline lights and installed in a handhole as indicated on the contract drawings. Each light shall be provided with lamp failure shorting device to allow the other lights to operate if one lamp fails. Lights shall be connected to secondary circuit wires at fixture leads using preinsulated watertight connector sleeves crimped with a tool that requires a complete crimp before tool can be removed. Connection shall be at staggered locations and wrapped with one layer of half-lapped plastic electrical insulating tape. Light fixtures shall be installed in holes drilled in the pavement as indicated.

3.22.3 Touchdown Zone Lighting Installation

A light base shall be provided for each light and transformer as indicated. In making cable connections, sufficient slack cable shall be provided in each base to permit connection to the upper part of the base or as indicated.

3.23 APPROACH LIGHTING SYSTEMS

Install approach lighting system as indicated or as required otherwise. Provide nameplates for equipment, controls, devices, and for each lighting circuit.

3.23.1 Frangible Requirements

At the 300 m (1,000 foot) crossbar and beyond, overrun lights shall be mounted up to 1.8 m (6 feet) above concrete foundations on threaded frangible couplings and 53 mm (2 inch) rigid steel conduit. For mounting heights greater than 1.8 m (6 feet), light shall be installed on low impact-resistant (LIR) frangible supports. When rigid towers, trestles, and similar structures are required, the light unit shall be installed at least 6 m (20 feet) above the rigid structure with this support unit being frangible.

3.23.2 Alignment of Lights

Align the approach lights with the axes of the beams directed towards the approach area parallel to the runway centerline. Vertically, they shall be aimed above the horizontal at the threshold of 5.5 degrees and increasing the elevation angle 0.5 degree for each 150 m (500 foot) interval into the approach area from the threshold. The tolerance for vertical aiming is plus or minus 0.5 degree.

3.24 FIELD QUALITY CONTROL

Notify the Contracting Officer five working days prior to each test. Submit performance test reports, upon completion and testing of the installed system, in booklet form showing all field tests performed to adjust each component and all field tests performed to provide compliance with the specified performance criteria. Each test shall indicate the final position of controls. Deficiencies found shall be corrected and tests repeated. Field test reports shall be written, signed and provided as each circuit or installation item is completed. Field tests shall include resistance-to-ground and resistance between conductors, and continuity measurements for each circuit. For each series circuit the input voltage and output current of the constant current regulator at each intensity shall be measured. For multiple circuits the input and output voltage of the transformer for each intensity setting shall be measured. A visual inspection of the lights operation, or of the markings appearance, or of the installation of fixtures or units installed shall be reported.

3.24.1 Operating Test

Test each completed circuit installation for operation. Equipment shall be demonstrated to operate in accordance with the requirements of this Section. One day and one night test shall be conducted for the Contracting Officer.

3.24.2 Distribution Conductors, 600-Volt Class

Test shall verify that no short circuits or accidental grounds exist using an instrument which applies a voltage of approximately 500 volts providing a direct reading in resistance.

3.24.3 Counterpoise System Test and Inspection

Continuity of counterpoise system shall be checked by visual inspection at accessible locations. Continuity of counterpoise system to the vault grounding system shall be tested in manhole closest to the vault.

3.24.4 Progress Testing for Series Lighting Circuits

A megger test shall be conducted on each section of circuit or progressive combinations of sections as they are installed. Each section or progressive combination of sections shall be tested with a megohmmeter providing a voltage of approximately 1000 volts, a direct reading in resistance. Results shall be documented. Faults indicated by these tests shall be eliminated before proceeding with the circuit installation.

3.24.5 Electrical Acceptance Tests

Acceptance tests shall be performed for series and multiple airfield and heliport lighting circuits only on complete lighting circuits. Each series and multiple lighting circuit shall receive a high voltage insulation test.

3.24.5.1 Low-Voltage Continuity Tests

Each series circuit shall be tested for electrical continuity. Faults indicated by this test shall be eliminated before proceeding with the high-voltage insulation resistance test.

3.24.5.2 High-Voltage Insulation Resistance Tests

Each series lighting circuit shall be subjected to a high-voltage insulation resistance test by measurement of the insulation leakage current with a suitable high-voltage test instrument which has a steady, filtered direct current output voltage and limited current. High-voltage tester shall include an accurate voltmeter and microammeter for reading voltage applied to the circuit and resultant insulation leakage current. Voltages shall not exceed test values specified below.

3.24.5.2.1 Test Procedure

Both leads shall be disconnected from regulator output terminals and support so that air gaps of several inches exist between bare conductors and ground. Cable sheaths shall be cleaned and dried for a distance of 300 mm (1 foot) from ends of cables and exposed insulation at ends of cables. Ends of both conductors of the circuit shall be connected together and to high-voltage terminals of test equipment, and test voltage applied as specified in the following tabulation between conductors and ground for a period of 5 minutes.

	Test Voltage, dc	
Series Lighting Circuits	First Test on New Circuits	Test on Existing Circuits
High Intensity Series Lighting Circuits (5,000-Volt Leads, 500- and 200-Watt Transformers)	9000	5000
Medium Intensity Series Lighting Circuits (5,000-Volt Leads, 30/45-Watt Transformers)	6000	3000
600-Volt Circuits	1800	6000
When additions are made to existing circuits, only new sections shall be tested in accordance with "First Test on New Circuits" in this table. To ensure reliable operation, complete circuit shall be tested at reduced voltages indicated.		

3.24.5.2.2 Leakage Current

Insulation leakage current shall be measured and recorded for each circuit after a 1 minute application of the test voltage. If leakage current exceeds values specified below, the circuit shall be sectionalized and retested and the defective parts shall be repaired or replaced. Leakage current limits include allowances for the normal number of connectors and splices for each circuit as follows:

a. Three microamperes for each 300 m (1000 feet) of cable.

b. Two microamperes for each 200 watt and each 500 watt 5,000-volt series transformer.

c. Two microamperes for each 30/45-Watt 5,000 volt series transformer.

d. If measured value of insulation leakage current exceeds calculated value, the circuit shall be sectionalized and tested as specified for each section. Defective components shall be repaired or replaced until repeated tests indicate an acceptable value of leakage current for the entire circuit.

3.24.6 Constant Current Regulators

Each constant current regulator shall be examined to ensure that porcelain bushings are not cracked, no shipping damage has occurred, internal and external connections are correct, switches and relays operate freely and are not tied or blocked, fuses, if required, are correct, and liquid level of liquid-filled regulators is correct. Relay panel covers shall be removed only for this examination; it is not necessary to open the main tank of liquid-filled regulators. The instructions on the plates attached to the regulators shall be followed. Covers shall be replaced tightly after completing examinations and tests.

3.24.7 Regulator Electrical Tests

Supply voltage and input tap shall correspond. With the loads disconnected, regulator shall be energized and the open circuit protector observed to ensure that it de-energizes the regulator within 3 seconds. After testing circuits for open circuit and ground fault and corrections, if any, and after determining that lamps are serviceable and in place, the loads shall be connected for each circuit or combination of circuits to be energized by the regulator and the voltage and current measured simultaneously for each brightness tap. Voltmeter and ammeter shall have an accuracy of plus or minus 1 percent of meter full scale. Readings shall be recorded during the day and night in order to obtain the average supply voltage. Output current on each brightness tap shall be within plus or minus 2 percent full scale of the nameplate values after making necessary correction in the supply voltage. Late model regulators have automatic supply voltage correction in lieu of input taps, and output current does not change as supply voltage varies. When output current on highest intensity setting deviates from nameplate value by more than 2 percent of meter full scale and the regulator is not overloaded, internal adjustment shall be checked as described on regulator instruction plate. Since adjustment may be rather delicate, a deviation of up to plus or minus 5 percent of meter full scale is allowed for lower intensity settings before attempting to readjust the regulator.

3.25 FINISHING

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as required in Section 09 90 00 PAINTS AND COATINGS.

3.26 TRAINING

Submit requirements of training 8 weeks before training is scheduled to begin. Submit information describing training to be provided, training aids to be used, samples of training materials, and schedules; a list of parts and components for the system by manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delays; instructions necessary to checkout, troubleshoot, repair, and replace components of the systems, including integrated electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting after acceptance of the system.

a. Provide training on the proper operation and maintenance procedures for the system. Submit a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

b. Submit one copy and one digital copy(pdf-text searchable) of operation for the equipment furnished within 7 calendar days following the completion of tests. One complete set shall be furnished prior to performance testing and the remainder shall be furnished upon acceptance. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

c. Submit one copy and one digital copy(pdf-text searchable) of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include conduit and equipment layout and simplified wiring and control diagrams of the system as installed.

3.27 FINAL OPERATING TESTS

After completion of installations and the above tests, circuits, control equipment, and lights covered by the contract shall be demonstrated to be in acceptable operating condition. Each switch in the control tower lighting panels shall be operated so that each switch position is engaged at least twice. During this process, lights and associated equipment shall be observed to determine that each switch properly controls the corresponding circuit. Telephone or radio communication shall be provided between the operator and the observer. Tests shall be repeated from the alternate control station, from the remote control points, and again from the local control switches on the regulators. Each lighting circuit shall be tested by operating the lamps at maximum brightness for not less than 30 minutes. At the beginning and at the end of this test the correct number of lights shall be observed to be burning at full brightness. One day and one night operating test shall be conducted for the Contracting Officer.

3.28 POSTED INSTRUCTIONS

Submit a typed copy of the proposed posted instructions showing wiring, control diagrams, complete layout and operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system.

-- End of Section --

SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2013) Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596	(2011) Indoor Optical Fiber Cables
ICEA S-90-661	(2008) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables for Use in General Purpose and LAN Communications Wiring Systems Technical Requirements

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568	(2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66	(2001; Errata 2003) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607	(2002a) Commercial Building Grounding

	(Earthing) and Bonding Requirements for Telecommunications
TIA-1152	(2009) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA-455-21	(1988; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-7	(2002; R 2008) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-C.0	(2009; Add 1 2010) Generic Telecommunications Cabling for Customer Premises
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.2	(2009; Errata 2010) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-C.3	(2008; Corrections 2008) Optical Fiber Cabling Components Standard
TIA-569	(2012c; Addendum 1 2013; Errata 2013) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-570	(2004b; Adm 1 2009; R 2010) Residential Telecommunications Infrastructure Standard
TIA/EIA-598	(2005c) Optical Fiber Cable Color Coding
TIA/EIA-604-10	(2002a) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC
TIA/EIA-604-12	(2000) FOCIS 12 Fiber Optic Connector Intermateability Standard Type MT-RJ
TIA/EIA-604-2	(2004b) FOCIS 2 Fiber Optic Connector Intermateability Standard
TIA/EIA-604-3	(2000b) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3
TIA/EIA-606	(2002a; Errata 2007; R 2007; Adm 1 2008) Administration Standard for the Telecommunications Infrastructure

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 1286	(2008; Reprint Sep 2011) Office Furnishings
UL 1666	(2007; Reprint May 2011) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Aug 2008) Communication Circuit Accessories
UL 444	(2008; Reprint Apr 2010) Communications Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 514C	(2014) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 723	(2008; Reprint Aug 2013) Test for Surface Burning Characteristics of Building Materials
UL 969	(1995; Reprint Nov 2008) Standard for Marking and Labeling Systems

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, TIA/EIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications cabling (backbone and horizontal); G

Patch panels; G

Telecommunications outlet/connector assemblies; G

Equipment support frame; G

Connector blocks; G

Spare Parts

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications cabling testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test plan; G

SD-09 Manufacturer's Field Reports

Factory reel tests; G

SD-10 Operation and Maintenance Data

Telecommunications cabling and pathway system Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide registered communications distribution designer (RCDD) approved, drawings in accordance with TIA/EIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA/EIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, BD's, and FD's to the telecommunications work area outlets. Provide a plastic laminated schematic of the as-installed telecommunications cable system showing cabling, CD's, BD's, FD's, and the EF and ER for telecommunications keyed to floor plans by room number. Mount the laminated schematic in the EF telecommunications space as directed by the Contracting Officer. The following drawings shall be provided as a minimum:

a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.

b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID’S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.

c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA/EIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard, and/or wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel require approval from the Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 0 to 60 degrees C (32 to 140 degrees F) and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs

TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA/EIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA/EIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA/EIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA/EIA-606. Documentation shall include the required data fields only in accordance with TIA/EIA-606.

1.10.3 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking.

PART 2 PRODUCTS

2.1 COMPONENTS

Comments shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568-C.0, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 and NFPA 70. Provide a labeling system for cabling as required by TIA/EIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Backbone Cabling

2.3.1.1 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568-C.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 1 meter (40 inches).

Provide the number of strands indicated, (but not less than 12 strands between the main telecommunication room and each of the other telecommunication rooms), of single-mode(OS1), tight buffered fiber optic cable.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

Provide plenum (OFNP), riser (OFNR) , or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568-C.1.

2.3.2.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568-C.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661. Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a blue thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70. Provide residential Category 6 cabling in accordance with TIA-570.

2.3.2.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596and TIA-568-C.3. Cable shall be tight buffered, single-mode, 8/125-um diameter, OS1. Cable shall be imprinted with manufacturer, flammability rating and fiber count at regular intervals not to exceed 1 meter (40 inches).

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.Cables installed in conduit within and under slabs be UL listed and labeled for wet locations in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding of cordage jacket, fiber, unit, and group in accordance with TIA/EIA-598.

2.3.3 Work Area Cabling

2.3.3.1 Work Area Copper

Provide work area copper cable in accordance with TIA-568-C.2, with a blue, thermoplastic jacket.

2.3.3.2 Work Area Optical Fiber

Provide optical work area cable in accordance with TIA-568-C.3.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment room or rooms to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA/EIA-606.

2.4.1 Backboards

Provide void-free, interior grade A-C plywood 19 mm (3/4 inch) thick 1200 by 2400 mm (4 by 8 feet). Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Paint applied over fire retardant backboard shall be UL 723 fire retardant paint. Provide label including paint manufacturer, date painted, UL listing and name of Installer. When painted, paint label and fire stamp shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces.

2.4.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

a. Bracket, wall mounted, 8 gauge aluminum. Provide hinged bracket compatible with 482.6 mm (19 inches) or 584 mm (23 inches) panel mounting.

b. Racks, floor mounted modular type, 16 gauge steel or 11 gauge aluminum construction, minimum, treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a surge protected power strip with 6 duplex 20 amp receptacles. Rack shall be compatible with 482.6 mm (19 inches) or 584 mm (23 inches) panel mounting, as indicated on drawing.

c. Cabinets, freestanding modular type, 11 gauge aluminum construction, minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. Cabinet shall be vented in the roof and rear door. Cabinet shall have cable access in the roof and base and be compatible with 482.6 mm (19 inches) or 584 mm (23 inches) panel mounting. Provide cabinet with grounding bar, rack or roof mounted 15 cu. m 550 CFM fan with filter, and a surge protected power strip with 6 duplex 20 amp receptacles. All cabinets shall be keyed alike.

d. Cabinets, wall-mounted modular type, 11 gauge aluminum construction, minimum, treated to resist corrosion. Cabinet shall have lockable front and rear doors, louvered side panels, 7 cu. m (250 CFM) roof or rack mounted fan, ground lug, and top and bottom cable access. Cabinet shall be compatible with 482.6 mm (19 inches)or 584 mm (23 inches) panel mounting. All cabinets shall be keyed alike. A surge protected power strip with 6 duplex 20 amp receptacles shall be provided within the cabinet.

2.4.3 Connector Blocks

Provide insulation displacement connector (IDC) Type 110 for Category 6 systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

2.4.4 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 482.6 or 584 mm (19 or 23 inches) equipment racks or cabinets and telecommunications backboards. Cable guides of ring or bracket type devices mounted on rack, cabinet, panels, or backboard for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, nuts, and lock washers.

2.4.5 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568-C.3. Patch cords shall meet minimum performance requirements specified in TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3 for cables, cable length and hardware specified.

2.4.5.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568-C.1 and TIA-568-C.2. Panels shall be third party verified and shall comply with EIA/TIA Category 6 requirements. Panel shall be constructed of 2.2 mm (0.09 inches) minimum aluminum and shall be cabinet, rack, or wall mounted and compatible with an ECIA EIA/ECA 310-E 482.6 mm (19 inches) or 584 mm (23 inches) equipment cabinet or rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A or T568B. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.5.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 11 gauge aluminum minimum and shall be cabinet, rack, or wall mounted and compatible with a ECIA EIA/ECA 310-E 482.6 mm (19 inches) or 584 mm (23 inches) equipment rack. Each panel shall provide 12 single-mode adapters as duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic, MT-RJ in accordance with TIA/EIA-604-12 with thermoplastic, or ST in accordance with TIA/EIA-604-2 with metallic alignment sleeves. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 203 mm (8 inches) deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

2.4.6 Optical Fiber Distribution Panel

Cabinet, rack, or wall mounted optical fiber distribution panel (OFDP) shall be constructed in accordance with ECIA EIA/ECA 310-E utilizing 16 or 18 gauge steel or 11 gauge aluminum minimum. Panel shall be divided into two sections, distribution and user. Distribution section shall have strain relief, routing guides, splice tray and shall be lockable, user section shall have a cover for patch cord protection. Each panel shall provide 12 single-mode pigtails and adapters. Provide adapters as duplex LC with zirconia ceramic alignment sleeves or duplex SC with zirconia ceramic ceramic sleeves, or adapters with alignment sleeves as indicated on drawings. alignment sleeves. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 Outlet/Connector Copper

Outlet/connectors shall comply with FCC Part 68, TIA-568-C.1, and TIA-568-C.2. UTP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568-C.2 Category 6 requirements. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each outlet/connector shall be wired T568A or T568B, as indicated. UTP outlet/connectors shall comply with TIA-568-C.2 for 200 mating cycles. UTP outlet/connectors installed in outdoor or marine environments shall be jell-filled type containing an anti-corrosive, memory retaining compound.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves or duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves, MT-RJ in accordance with TIA/EIA-604-12 with thermoplastic alignment sleeves, or ST in accordance with TIA/EIA-604-2 with metallic alignment sleeves as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for mating cycles.

2.5.3 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic, MT-RJ in accordance with TIA/EIA-604-12 with thermoplastic, or ST in accordance with TIA/EIA-604-2 with metallic ferrule, epoxy-less compatible with 8/125 single-mode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at wavelength indicated on drawings with less than a 0.2 dB change after 500 mating cycles.

2.5.4 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568-C.1, TIA-568-C.2, or TIA-568-C.3, as indicated; flush or oversized design constructed of high impact thermoplastic material to match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, 302 stainless material, or brass material. Provide labeling in accordance with the paragraph LABELING in this section.

2.6 MULTI-USER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

Provide MUTOA(s) in accordance with TIA-568-C.1.

2.7 TERMINAL CABINETS

Construct of zinc-coated sheet steel, 915 by 610 by 150 mm (36 by 24 by 6 inches) deep. Trim shall be fitted with hinged door and locking latch. Doors shall be maximum size openings to box interiors. Boxes shall be provided with 16 mm (5/8 inch) backboard with two-coat varnish finish. Match trim, hardware, doors, and finishes with panelboards. Provide label and identification systems for telecommunications wiring and components consistent with TIA/EIA-606.

2.8 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA J-STD-607, and NFPA 70. Components shall be identified as required by TIA/EIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.9 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.10 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.11 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inches) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (1.0 by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inches) high normal block style.

2.12 TESTS, INSPECTIONS, AND VERIFICATIONS

2.12.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-526-7 for single mode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568-C.1, TIA-568-C.2, TIA-569, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install UTP, and optical fiber telecommunications cabling system as detailed in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 and TIA-570 for residential cabling. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 110 N (25 pounds) pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Open Cable

Use only where specifically indicated on plans for use in cable trays, or below raised floors. Install in accordance with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3. Do not exceed cable pull tensions recommended by the manufacturer. Copper cable not in a wireway or pathway shall be suspended a minimum of 200 mm (8 inches) above ceilings by cable supports no greater than 1.5 m (60 inches) apart. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 300 mm (12 inches) shall be maintained when such placement cannot be avoided.

Plenum cable shall be used where open cables are routed through plenum areas. Cable routed exposed under raised floors shall be plenum rated. Plenum cables shall comply with flammability plenum requirements of NFPA 70. Install cabling after the flooring system has been installed in raised floor areas. Cable 1.8 meters (6 feet) long shall be neatly coiled not less than 300 mm (12 inches) in diameter below each feed point in raised floor areas.

3.1.1.2 Backbone Cable

a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in indicated pathways, between the campus distributor, located in the telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.

b. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 250 mm (10 inches) leaving strength members exposed for approximately 250 mm (10 inches). Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.3 Horizontal Cabling

Install horizontal cabling as indicated on drawings Do not untwist Category 6 UTP cables more than 12 mm (.5 inch) from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, 3 m (10 feet) in the telecommunications room, and 304 mm (12 inches) in the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Service Entrance Conduit, Overhead

Provide service entrance overhead as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEMS.

3.1.4 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.5 Cable Tray Installation

Install cable tray as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Only CMP and OFNP type cable shall be installed in a plenum.

3.1.6 Work Area Outlets

3.1.6.1 Terminations

Terminate UTP cable in accordance with TIA-568-C.1, TIA-568-C.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA-568-C.3

3.1.6.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.6.3 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 304 mm (12 inches) of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.6.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.6.5 Multi-User Telecommunications Outlet Assembly (MUTOA)

Run horizontal cable in the ceiling or underneath the floor and terminate each cable on a MUTOA in each individual zone. MUTOAs shall not be located in ceiling spaces, or any obstructed area. MUTOAs shall not be installed in furniture unless that unit of furniture is permanently secured to the building structure. MUTOAs shall be located in an open work area so that each furniture cluster is served by at least one MUTOA. The MUTOA shall be limited to serving a maximum of twelve work areas. Maximum work area cable length requirements shall also be taken into account. MUTOAs must be labeled to include the maximum length of work area cables. MUTOA labeling is in addition to the labeling described in TIA/EIA-606, or other applicable cabling administration standards. Work area cables extending from the MUTOA to the work area device must also be uniquely identified and labeled.

3.1.7 Telecommunications Space Termination

Install termination hardware required for Category 6 and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.7.1 Connector Blocks

Connector blocks shall be cabinet, rack, or wall mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.7.2 Patch Panels

Patch panels shall be mounted in equipment cabinets, racks, or on plywood backboard with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel with cable ties to prevent movement of the cable.

b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 900 mm (3 feet) in length or provided as recommended by the manufacturer. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.7.3 Equipment Support Frames

Install in accordance with TIA-569:

a. Bracket, wall mounted. Mount bracket to plywood backboard in accordance with manufacturer's recommendations. Mount rack so height of highest panel does not exceed 1980 mm (78 inches) above floor.

b. Racks, floor mounted modular type. Permanently anchor rack to the floor in accordance with manufacturer's recommendations.

c. Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets. Mount rack mounted fan in roof of cabinet.

d. Cabinets, wall-mounted modular type. Mount cabinet to plywood backboard in accordance with manufacturer's recommendations. Mount cabinet so height of highest panel does not exceed 1980 mm (78 inches) above floor.

3.1.8 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.9 Grounding and Bonding

Provide in accordance with TIA J-STD-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA/EIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using laser printer.

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA/EIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA/EIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.1 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568-C.1, TIA-568-C.2, or TIA-568-C.3. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, and TIA-570 for residential cabling. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568-C.3 and TIA-526-7 using Method B, OTDR for single-mode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

a. Perform Category 6 link tests in accordance with TIA-568-C.1 and TIA-568-C.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568-C.3.

c. Ensure all cables are routed and installed properly.

3.5.1.4 Final Verification Tests

Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.

b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 27 54 00.00 20

COMMUNITY ANTENNA TELEVISION (CATV) SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code

NATIONAL CABLE AND TELECOMMUNICATIONS ASSOCIATION (NCTA)

NCTA RP	(2003) NCTA Recommended Practices for Measurements on Cable Television Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 76.605	Technical Standards

UNDERWRITERS LABORATORIES (UL)

UL 969	(1995; Reprint Nov 2008) Standard for Marking and Labeling Systems

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, applies to this section with the additions and modifications specified herein.

1.3 DEFINITIONS

1.3.1 CATV

Community antenna television (CATV) system, commonly referred to as cable television, is a network of cables, head end, electronic and passive components that process and amplify television (TV) signals for distribution from the head end equipment to the individual television outlets.

1.3.2 Head end

The connection point between CATV system equipment and equipment provided by the local CATV company.

1.3.3 Distribution System

Distribution system transports and delivers adequate signals to each receiver. Provides distortion-free signal to TV sets by isolating each receiver from the system and by providing proper amount of signal to each set.

1.3.4 Cable

Drop cables are used to transport the desired signal used from the communications closet to the wall outlet.

1.4 SYSTEM DESCRIPTION

1.4.1 Head end

Contractor shall provide interior equipment up to CATV service and including theamplifier located at the interior CATV cabinet.

1.4.2 Distribution System

Distribution system shall be star topology with each outlet connected to head end equipment with the drop cable.

1.4.3 Cable

Provide drop cables to transport the desired signal from the communications closet to the outlet.

1.4.4 System Components

System shall provide high quality TV signals to all outlets with a return path for interactive television and cable modem access. Provide any combination of items specified herein to achieve required performance, subject to approvals, limitations, acceptance test, and other requirements specified herein. System shall include amplifiers, splitters, combiners, line taps, cables, outlets, tilt compensators and all other parts, components, and equipment necessary to provide a complete and usable system.

1.4.4.1 System Bandwidth

a. Downstream: 50-750 MHz minimum.

b. Upstream 5-40 MHz minimum.

1.4.5 System Performance

System shall be in compliance with 47 CFR 76.605.

1.4.5.1 Receiver Termination Signal Level

Each termination for a TV receiver must have a minimum signal level of 0 decibel millivolts (dBmV) (1000 microvolts) at 55 MHz and of 0 dBmV (1000 microvolts) at 750 MHz and a maximum signal of 15 dBmV or a level not to overload the receiver for the entire system bandwidth.

1.4.5.2 Distribution System

a. Modulation distortion at power frequencies: 4 percent or less hum distortion;

b. Composite third order distortion for:

(1) CW carriers: 53 dB.

(2) Modulated carriers: 59 dB.

c. Subscriber terminal isolation: 18 dB or greater.

d. Carrier to second order beat ratio: 60 dB.

e. Amplitude characteristic shall be within a range of plus or minus 2 decibels from 0.75 MHz to 5.0 MHz above the lower boundary frequency of the cable television channel, referenced to the average of the highest and lowest amplitudes within these frequency boundaries.

f. Visual, aural carrier level, 24-hour variation: 47 CFR 76.605, subpart (a), rules (4), (5), and (6).

g. Frequency determination: 47 CFR 76.605, subpart (a), rules (1),(2), and (3).

1.4.5.3 All New System Tolerance

The system shall not show a serious loss of carrier to noise when the system levels are lowered 3 dB below normal or a significant distortion when the levels are increased 3 dB above normal, as observed on a TV set located at the far end extremities of the system.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

CATV system wiring diagrams and installation details

SD-03 Product Data

Amplifiers, including head end, trunk, bridging, and distribution

Cables, including trunk, feeder, and drop

Terminators

Splitters

Outlets

Connectors

Grounding block

Submittals for each manufactured item shall be the current manufacturer's descriptive literature of catalog products, equipment drawings, diagrams, performance and characteristics curves, and catalog cuts.

SD-05 Design Data

CATV System Loss Calculations

SD-06 Test Reports

Acceptance tests

1.6 QUALITY ASSURANCE

1.6.1 Wiring Diagrams and Installation Details

Illustrate how each item of equipment functions in the system and include an overall system schematic indicating the relationship of CATV units on one diagram. Drawings shall include wiring diagrams and installation details of equipment indicating proposed locations, layout and arrangements, and other items that must be shown to ensure coordinated installation.

1.6.2 CATV System Loss Calculations

Calculations shall verify that the system does not exceed the loss values specified in dBmV at the input of all active devices and the receiver terminations. Provide a drawing displaying all distribution network calculations. The drawing should accurately show taps, splitters, outlets, and the type and length of all drop cables. The drawing shall show how many taps, splitters, or outlets are served by each tap or splitter.

1.6.3 Operational Test Plan

Test plan shall define tests required to ensure that the system meets technical, operational, and performance specifications. Test plan shall be based on NCTA RP and be in accordance with FCC proof of performance requirements. Test plan shall include plan for testing for signal leakage. Provide test requirements and guidelines.

1.6.4 Operational Test Procedures

Use test plan and design documents to develop test procedures. Procedures shall consist of detailed instructions for a test setup, execution, and evaluation of test results.

1.6.5 Connector Installation

Provide manufacturer's instructions for installing connectors.

PART 2 PRODUCTS

2.1 ELECTRONIC EQUIPMENT

Electronic components of similar type shall be produced and designed by the same manufacturer as major components of the equipment and shall have the manufacturer's name and model permanently attached. Equipment shall function properly as a complete integrated system. Equipment shall be shielded. The system shall be designed to operate within 5 to 1000 MHz bandwidth using 1000 MHz passive devices and a minimum of 750 MHz active devices.

2.2 DISTRIBUTION EQUIPMENT

2.2.1 Distribution Amplifiers

Distribution amplifiers shall be equipped for 75 ohms input and output impedance. Electronic equipment exposed to weather shall be equipped with weatherproof housings. Amplifiers shall be bidirectional with variable slope and gain control and shall amplify broadband signals from 50 to 750 MHz and provide an amplified return path for signals from 5 to 40 MHz for 75 ohms impedance.

2.2.2 Cables and Associated Hardware

Cabling shall be UL listed for the application and shall comply with NFPA 70. Provide a labeling system for cabling as required by UL 969. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.2.2.1 Drop Cable

UL 1581. Provide RG 6 coaxial cable with an NFPA 70 rating of CATV and with the following characteristics:

a. No. 18 AWG copper-clad steel center conductor.

b. Bonded foil inner-shield and 90 percent aluminum braid.

c. Characteristic impedance of 75 ohms.

d. Gas injected foam polyethylene or Foam FEP dielectric

e. Nominal capacitance, conductor to shield, of 53 pf per 100 m (16.2 pf per 100 ft) .

f. Maximum operating voltage of 350 V RMS.

g. Maximum attenuation:

CATV	
MHz	DB/100 m ft
10	2.59 0.81
50	5.08 1.46
100	7.19 2.05

CATV	
MHz	DB/100 m ft
200	10.17 2.83
400	14.38 4.0
500	15.48 4.53
700	19.02 6.0
1000	22.74 7.3

CATVP	
MHz	DB/100 m ft
10	2.3 0.7
50	4.9 1.5
100	6.9 2.1
200	10.2 3.1
400	14.8 4.5
500	19.7 6.0
700	22.6 6.9
1000	23.9 7.3

h. Black polyvinyl chloride (PVC)or PVC low smoke polymer or FEP jacket.

i. 100 percent sweep testing from 5 MHz to a minimum of 1000 MHz.

2.2.3 Terminators

Terminators shall be rated for 75 ohms and 1/4 watt.

2.2.4 Splitters

Use splitters with characteristics equal to or exceeding the characteristics listed in this paragraph over the entire operating band. All unused outlets must be terminated with 75-ohm terminators.

a. Peak to Valley: Not to exceed 1 dB across bandwidth of device.

b. Return loss: 18 dB minimum.

c. Bandwidth: 5-1000 Mhz

2.2.5 Outlets

Provide flush mounted, 75-ohm, F-type connector outlets rated from 5 to 1000 MHz in standard electrical outlet boxes.

2.2.6 Connectors

Provide one piece connectors. Drop cable connectors shall be feed thru type.

2.3 GROUNDING AND BONDING

Provide ground rods and connections in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3.1 Grounding Block

Provide corrosion-resistant grounding block suitable for outdooror indoor installation.

2.4 PULL BOX

Provide pull boxes, sized as indicated and painted with a gray, nonconductive fire-resistant overcoat..

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Distribution System

Distribution system shall conform to requirements specified herein. Installation shall be in accordance with IEEE C2 and NFPA 70.

3.1.1.1 Raceway

Provide cable installed in raceways such as conduit and cable trays in compliance with NFPA 70. Raceway shall comply with Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM.

3.1.1.2 Grounding System

Provide the grounding block at the service point of connection. Ground this device according to the requirements of IEEE C2 and NFPA 70.

3.1.1.3 Drop Cable

Provide cable to grounding blocks, to line taps, and to outlets.

3.2 FIELD QUALITY CONTROL

3.2.1 System Pretest

Upon completing installation of the CATV system, the Contractor shall align and balance the system and shall perform complete pretesting. During the system pretest, Contractor, utilizing the approved spectrum analyzer or signal level meter, shall verify that the system is fully operational and meets all the system performance requirements of the specification. Contractor shall test the signal loss in dBmV at 55, 151, 547, and 750 MHz. The signal levels shall be 0 dBmV (1000 microvolts), minimum. The signal shall not exceed 15 dBmV over the entire system bandwidth. Any deficiencies found shall be corrected and revalidated by follow up testing. Contractor shall measure and record the video and audio carrier levels at each of the frequency levels specified at each of the following points in the system:

a. Furthest outlet from service entrance point of connection.

b. Distribution amplifier inputs and outputs.

c. At each outlet.

3.2.2 Acceptance Tests

Contractor shall notify the Contracting Officer of system readiness 10 days prior to the date of acceptance testing. Contractor shall also coordinate with the local CATV provider and allow them to attend witness tests. CATV system shall be tested in accordance with the approved test plan in the presence of the Contracting Officer's representative to certify acceptable performance. System test shall verify that the total system meets all the requirements of the specification and complies with the specified standards. Contractor shall verify that no signal leakage exists in conformance with NCTA RP and 47 CFR 76.605. Deficiencies revealed by the testing shall be corrected on the outlets sampled as well as on the outlets not sampled and revalidated by follow-up testing. Contractor shall conduct testing at each of the following points in the system:

a. Furthest outlet from service entrance point of connection.

b. Distribution amplifier inputs and outputs.

c. At each outlet.

-- End of Section --

SECTION 28 31 33.00 10

FIRE ALARM REPORTING SYSTEM, RADIO TYPE
11/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 467	(2007) Grounding and Bonding Equipment
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel

1.2 SYSTEM DESCRIPTION

Provide a central reporting system complying with NFPA 72. The equipment furnished shall be listed by Underwriters Laboratories, or Factory Mutual Engineering and Research, or be approved or listed by a nationally recognized testing laboratory.

a. Furnish tags with stamped identification numbers for keys and locks. Locks shall be keyed alike. The radio system shall report alarms to the radio fire alarm monitoring base station. The system shall be a completely supervised radio type fire alarm reporting system.

b. Submit detail drawings, signed by the Registered Professional Engineer, consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical detectors. Check the layout based on the actual detectors to be installed and make any necessary revisions in the detail drawings.

c. Detail drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. The system shall indicate the area of alarm. The radio communication link shall be supervised and operated in accordance with NFPA 72. Electrical supervision shall be provided for all circuits and for all positions of interface panel control switches.

d. Submit one hard copy and one digital copy (.pdf - text searchable) of operating instructions outlining step-by-step procedures required for system startup, operation, and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features.

e. Submit one hard copy and one digital copy (.pdf - text searchable) of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The instructions shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. Instructions shall be approved prior to training.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fire Alarm Reporting System; G
Wiring for Systems

SD-03 Product Data

Battery
Spare Parts
Training
Test Procedures

SD-06 Test Reports

Testing

SD-07 Certificates

Equipment
Qualifications

SD-10 Operation and Maintenance Data

Fire Alarm Reporting System

1.4 QUALITY ASSURANCE

Provide the services of a qualified Fire Protection Engineer. Submit proof of qualifications for this engineer. For the purposes of meeting this requirement, a qualified fire protection engineer is defined as an individual meeting one of the following conditions:

a. A registered professional engineer (P.E.) in fire protection engineering.

b. A registered PE in a related engineering discipline and either member grade status in the National Society of Fire Protection Engineers or a minimum of 5 years of experience dedicated to fire protection engineering that can be verified with documentation.

c. An engineer with a minimum of 10 years' experience in fire protection engineering that can be verified with documentation and member grade status in the National Society of Fire Protection Engineers.

d. Individual who is certified as a Level III or IV Technician by the National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt, dust, and other contaminants.

1.6 SPECIAL TOOLS AND SPARE PARTS

Furnish special tools necessary for the maintenance of the equipment. Submit certified copies of current applicable approvals or listings issued by UL, FM or other nationally recognized testing laboratory showing equipment complies with applicable NFPA standards. Submit spare parts data for each different item of material and equipment specified, after approval of detail drawings, and not later than 10 days prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies with the current unit prices and source of supply and a list of the parts recommended by the manufacturer to be replaced after 1 year of service. Provide one spare set of fuses of each type and size required and 5 spare lamps of each type.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 NAMEPLATES

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and non-heat-sensitive plate which is securely attached to the equipment.

2.3 RADIO FIRE ALARM TRANSMITTER (TRANSCEIVER)

Radio Fire Alarm Transmitter (Transceiver) shall be compatible with the Radio Fire Alarm Monitoring Base Station. The transmitter (transceiver) shall be all solid state and comply with applicable portions of 47 CFR 15 governing type acceptance. All transmitters (transceivers) of a common configuration shall be interchangeable with the other devices furnished by the manufacturer. Each transmitter (transceiver) and interface device shall be the manufacturer's current commercial product completely assembled, wired, tested at the factory, and delivered ready for installation and operation.

2.3.1 Frequency Allocation

The transmitters (transceivers) shall operate on a frequency as indicated below:

a. AREA I
Uijongbu (Camp Red Cloud, Camp Stanley, Camp Jackson & Camp Kwangsa-ri): 138.6375 MHz
Dongduchon (Camp Casey, Camp Hovey, Camp Mobile, Camp Bonifas, Warrior Base, RLFC): 149.4125MHz
b. AREA II
Seoul: 149.4125 MHz
c. Area III
Pyongtaek (Camp Humphreys): 138.2500 MHz
d. Area IV
Daegu (Camp Henry, Camp Walker): 158.8125 MHz
Waegwan (Camp Carroll): 149.4125 MHz

2.3.2 Power Requirements

Transmitters (transceivers) shall be powered by a combination of locally available 120 Vac, and sealed nickel-cadmium or lead-acid type batteries requiring no additional water. In the event of loss of 120 Vac power, the transmitter (transceiver) shall automatically switch to battery operation. The switchover shall be accomplished with no interruption of protective service, without adversely affecting the battery-powered capabilities, and shall cause the transmission of a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall be automatic and the battery shall be recharged. The converter/battery charger shall be installed within the transmitter (transceiver) housing. Power supply transient filtering shall be provided.

2.3.2.1 Battery Power

The battery package shall be capable of supplying all the power requirements for a given transmitter (transceiver). Submit substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component, each panel component and the battery recharging period shall be included.

2.3.2.2 Battery Duration

Radio fire alarm transmitter (transceiver) standby battery capacity shall provide sufficient power to operate the transmitter (transceiver) in a normal standby status for a minimum of 60 hours and shall be capable of transmitting alarms during that period.

2.3.2.3 Battery Supervision

Each radio fire alarm transmitter (transceiver) shall constantly monitor and supervise its own battery powered supply. A low-battery condition shall be reported when battery voltage falls below 85 percent of the rated voltage.

2.3.3 Functional Requirements

2.3.3.1 Interfacing Indicators and Controls

Transmitters (transceivers) shall incorporate the provisions for auxiliary interconnection to existing interior alarm systems.

2.3.3.2 Generation of Signals

Each transmitter (transceiver) shall be a standard design which allows the immediate transmission of all initiated signals.

2.3.3.3 Power Output

The radio frequency (RF) power output of each transmitter (transceiver) shall be sufficient for reliable alarm reporting. The minimum RF power output shall be 1 watt.

2.3.3.4 Memory

Transmitters (transceivers) shall have memory capability. Multiple, simultaneous alarms shall not result in the loss of any messages. Messages shall be stored until they are transmitted.

2.3.3.5 Transmitter (Transceiver) Identity Code

Each transmitter (transceiver) shall transmit a distinct identity code number as part of all signals emanating from the transmitter (transceiver). The identity code shall be transmitted not less than three complete rounds (cycles).

2.3.3.6 Message Designations

Each transmitter (transceiver) shall allow as a minimum no less than 10 distinct and individually identifiable message designations as to the types or causes of transmitter (transceiver) actuation.

a. Master Message: Master messages shall be transmitted upon automatic actuation of the transmitter (transceiver). The building and zone causing actuation shall be individually identified as part of this transmission. The transmitter (transceiver) shall be capable of identifying and transmitting master (zone) messages.

b. Test Message: Test message shall be capable of both manual and automatic actuation. When a transceiver method is employed, it shall provide for automatic interrogation at preselected periods or continuous automatic interrogation in accordance with the governing standard. Additionally, transceiver systems shall provide for selective interrogation at times determined by the user. Testing the automatic test actuation shall occur a minimum of once in each 24-hour period, at an optionally preselected time. Stability of the electronic actuating device shall be plus or minus 1 minute per month within the temperature range stipulated for system operation. Actuation of the "Test" message designation, regardless of initiating means, shall cause no less than 1 complete message to be sent.

c. Tamper Message Designation: The tamper message shall be automatically transmitted when a tamper switch is tripped in the transmitter (transceiver) housing.

d. Trouble Message Designation: Trouble message shall be automatically transmitted in the event of a failure in excess of 1 minute of the main operating power source of the transmitter (transceiver).

2.3.4 Transmitter (Transceiver) Housings

The housings on transmitters (transceivers)shall be fabricated from corrosion-resistant cast metal or suitable substitute which has the physical strength sufficient to ward off physical damage normally expected to be received by vandalism. The housing shall be sealed against the entry of moisture, dust, dirt, insects, and other foreign objects. Exterior housings shall be NEMA 4X.

2.3.4.1 Lock

Internal components shall be protected from vandalism by a tamper-proof lock on the transmitter (transceiver) housing. The housing shall allow access to all internal components for testing, servicing, and replacement at the installation site.

2.3.4.2 Mounting

Transmitter (transceiver) housings shall be designed for universal mounting on walls, poles, or pedestals. Mounting shall utilize either lag bolts, anchor bolts, stainless steel banding, mounting brackets, or a shackle/bolt combination, as applicable to the specific installation.

2.3.5 Environmental Operating Requirements

The transmitter (transceiver) shall be designed for reliable outside operation in an ambient temperature range of -30 to 60 degrees C (-22 to 140 degrees F). Transmitters (Transceivers) shall be corrosion-resistant and designed for reliable operation under adverse climatic conditions including 160.9 km/hour (100 mph) winds, ice, rain, and snow storms.

2.3.6 Painting

Radio fire alarm transmitter (transceiver) and interface housings shall be factory painted. The finish color shall be fire engine red. Painted surfaces damaged during installation shall be repainted to match existing paint.

2.4 FIRE ALARM SYSTEM PERIPHERAL EQUIPMENT

2.4.1 Repeaters

Repeaters shall be provided where indicated or required to meet system requirements. The receiver and transmitter sections shall conform to the requirements specified for transceivers. Two-way data transmission shall be relayed between the base station and remote stations. Repeater shall utilize a bandpass-type duplexer and one antenna, or multiple-bandpass cavity filters and multiple antennas. The duplexer or filter cavities shall isolate the receiver from transmitter spurious noise and prevent receiver desensitization. The duplexer or filter cavities shall be rated to handle the output power of the transmitter. Repeater shall be keyed with tone-encoded control circuit. A transmitter time-out circuit shall be provided to prevent system lockup.

2.4.2 Conduit

Conduit and fittings shall comply with UL 6, UL 1242, and UL 797.

2.4.3 Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467 not less than 19 mm(3/4 inch) in diameter by 2.5 m (8 feet in length.

2.4.4 Power Supply

The operating power for the system shall be single phase taken from the building electric service as specified in paragraph Power Supply for the System. Emergency backup power shall be provided by sealed lead-acid or nickel-calcium type batteries requiring no additional water. The charging system shall recharge fully discharged batteries within 12 hours and maintain the batteries in the fully charged state. The battery shall have the capacity to operate the system for not less than 48 hours under maximum normal load with the power supply to the charger disconnected.

2.4.5 Wiring

Wiring shall be in accordance with NFPA 70 and as indicated. Station wiring shall be color coded.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Perform installation as shown and in accordance with the manufacturer's recommendations, unless otherwise specified. Provide all necessary interconnections, services, and adjustments required for a complete and operational system. Electrical work shall be in accordance with NFPA 70.

3.2.1 Power Supply for the System

Provide a single dedicated branch-circuit connection for supplying power to the fire alarm system. The backup power supply shall be automatically energized upon failure of the normal power supply.

3.2.2 Wiring for Systems

Wiring for systems shall be installed in rigid conduit or electric metallic tubing. The conductors for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. The sum of the cross-sectional areas of individual conductors shall not exceed 40 percent of the interior cross-sectional area of the conduit. Conduit shall comply with NFPA 70. Provide ample gutter space to accommodate necessary wiring. Submit detail point-to-point wiring diagram, signed by the Registered Professional Engineer, showing all points of connection. Diagram shall include connections between system devices, appliances, control panels, supervised devices, an all equipment that is activated or controlled by the panel.

3.3 OVERVOLTAGE AND SURGE PROTECTION

Equipment connected to alternating current circuits shall be protected from surges in accordance with IEEE C62.41.1, IEEE C62.41.2 and NFPA 70. Cables and conductors which serve as communications links, except fiber optics, shall have surge protection circuits installed at each end. Fuses shall not be used for surge protection.

3.4 GROUNDING

Ground rods shall not protrude more than 150 mm (6 inches) above grade. Noncurrent-carrying metallic parts associated with radio fire alarm equipment shall have a maximum resistance to solid "earth" ground not to exceed 25 ohms.

3.5 TRAINING

Conduct a training course for operating staff in the building where the system is installed as designated by the Contracting Officer. The training period shall consist of 4 hours and shall start after the system is functionally completed but prior to the final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance instructions.

3.6 TESTING

Submit test reports in booklet form showing field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document all readings, test results, and indicate the final position of controls. Notify the Contracting Officer 15 days before the performance and acceptance tests are to be conducted and submit the test procedures to be used. Submit detailed test procedures for the fire alarm reporting system 10 days prior to performing system tests. The test procedures shall be signed by the Registered Professional Engineer. Perform the tests in the presence of the Contracting Officer under the supervision of the fire alarm system manufacturer's qualified representative. Furnish all instruments and personnel required for the tests.

3.6.1 Performance Testing

Upon completion of the installation, the system shall be subjected to a complete functional and operational performance test. Test shall determine that the system is free from grounded, shorted, or open circuits. When all corrections have been made, the system shall be retested to assure that it is functional. Copies of performance test reports shall be submitted in accordance with paragraph SUBMITTALS.

3.6.2 Acceptance Test

The testing shall be in accordance with NFPA 72. The recommended tests in NFPA 72 shall be considered mandatory and shall verify that all previous deficiencies have been corrected. The tests shall include the following:

a. Tests to indicate there are no grounded, shorted, or open circuits.

b. Tests of each radio fire alarm transmitter/receiver/transceiver/ repeater.

d. Tests of normal and emergency power supplies.

-- End of Section --

SECTION 28 31 49

CARBON MONOXIDE DETECTORS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 2034	(2008; Reprint Feb 2009) Single and Multiple Station Carbon Monoxide Alarms
UL 2075	(2013) Standard for Gas and Vapor Detectors and Sensors

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Carbon monoxide detector; G

SD-06 Test Reports

Carbon monoxide detector test

SD-10 Operation and Maintenance Data

As-Built Drawings; G

PART 2 PRODUCTS

2.1 CARBON MONOXIDE DETECTOR

UL 2075, Gas and Vapor Detectors and Sensors(System connected CO Alarms), surface, and flush mounted. Operational requirements shall be as follows:

a. Electrical: 120 Volt AC, 12/24 Volt DC

b. Environmental: 0 degrees to 40 degrees C (32 degrees to 104 degrees F)

c. Alarm and Indicator: Red LED for visual and 85 db at 3050 mm (10 ft) for audible alarm. Malfunction indicator light shall be yellow or amber LED. Power on indicator light shall be white or green. Activation of a carbon monoxide detection device shall initiate a voice notification message distinctly different from a fire alarm notification and transmit a unique signal/message to the fire alarm contort panel. System-connected CO detectors incorporate and integral trouble relay that sends a trouble signal to the fire alarm control panel when CO sensor has reached its EOL(end-of-life).

d. Alarm thresholds: The alarm thresholds, set by CO concentration measured in parts per million(ppm), are: no alarm below 30 ppm until after 30 days; 70 ppm for one to four hours(but not less than one hour); 150 ppm for 10 to 50 minutes; 400 ppm for four to 15 minutes.

2.2 CONDUIT, BOXES, AND FITTINGS

Specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3 WIRES AND CABLES

Specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and NFPA 72.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Electrical and control work

Electrical and control wiring shall conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, NFPA 70, and NFPA 72.

3.1.2 Carbon Monoxide Detector

Install detectors in accordance with NFPA 720 and the manufacturer's instructions.

3.1.3 Grounding and Bonding

Equipment grounding and bonding shall be in accordance with UL 2034, UL 2075, and NFPA 70.

3.2 FIELD QUALITY CONTROL

Provide test equipment and personnel and submit written copies of the test results. Notify Contracting Officer 15 working days prior to the test.

3.2.1 Carbon Monoxide Detector Test

Contractor shall show by demonstration in service that system-connected CO alarm systems are in good condition and properly performing the intended function. Test shall be in accordance with UL 2075 requirements, and the manufacturer's test procedure.

3.2.2 As-Built Drawings

Provide one hard copy & one digital copy of As-Built Drawings to the Contracting Officer for approval. Submit in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

-- End of Section --

SECTION 28 31 64.00 10

FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE
08/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.41	(1990; R 2008) Audible Emergency Evacuation Signal (ASA 96)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1221	(2010) Standard for the Installation, Maintenance and Use of Emergency Services Communications Systems
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1242	(2006; Reprint Mar 2014) Standard for

	Electrical Intermediate Metal Conduit -- Steel
UL 1971	(2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
UL 228	(2006; Reprint Nov 2008) Door Closers-Holders, With or Without Integral Smoke Detectors
UL 268	(2009) Smoke Detectors for Fire Alarm Systems
UL 268A	(2008; Reprint Sep 2009) Smoke Detectors for Duct Application
UL 38	(2008; Reprint Dec 2008) Manual Signaling Boxes for Fire Alarm Systems
UL 464	(2009; Reprint Apr 2012) Standard for Audible Signal Appliances
UL 521	(1999; Reprint May 2010) Heat Detectors for Fire Protective Signaling Systems
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 864	(2003; Reprint Aug 2012) Standard for Control Units and Accessories for Fire Alarm Systems

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 8401	(2010) Rigid Steel Conduits
KS C 8422	(2010) Flexible Metal Conduit
KS C 8431	(2009) Rigid Unplasticized Polyvinyl Chloride (UPVC) Conduits
KS C 8458	(2012) Boxes and Box Cover for Rigid Metal Conduits
KS C 8459	(2010) Fittings for Flexible Metal Conduits
KS C 8460	(2010) Fittings for Rigid Metal Conduits
KS C 8461	(2010) Surface Accessory for Rigid Metal Conduits

1.2 SYSTEM DESCRIPTION

The fire detection and alarm system and the central reporting system shall be a complete, supervised fire alarm reporting system configured in accordance with NFPA 72; exceptions are acceptable as directed by the

Contracting Officer. Furnish equipment compatible and UL listed, FM approved, or approved or listed by a nationally recognized testing laboratory in accordance with the applicable NFPA standards. Locks shall be keyed alike. Provide four keys for the system. Furnish tags with stamped identification number for keys and locks.

1.2.1 Operation

Activate the system into the alarm mode by actuation of any alarm initiating device. The system will remain in the alarm mode until the initiating device is reset and the fire alarm control panel is reset and restored to normal. Alarm and supervisory initiating devices shall be individually addressable. Alarm initiating devices shall be connected to initiating device circuits (IDC), Class A, to signal line circuits (SLC), Class A, in accordance with NFPA 72. Connect alarm notification appliances to notification appliance circuits (NAC), Class A in accordance with NFPA 72. Provide a looped conduit system so that if the conduit and all conductors within are severed at any point, all IDC, NAC and SLC will remain functional. The conduit loop requirement is not applicable to the signal transmission link from the local panels (at the protected premises) to the Supervising Station (fire station, fire alarm central communication center). Textual, audible, and visual appliances and systems shall comply with NFPA 72. Fire alarm system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc. Addressable system shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits and shall provide the following features:

a. Sufficient memory to perform as specified and as shown for addressable system.

b. Individual identity of each addressable device for the following conditions: alarm; trouble; open; short; and appliances missing/failed remote detector - sensitivity adjustment from the panel for smoke detectors.

c. Capability of each addressable device being individually disabled or enabled from the panel.

d. Size each SLC to provide 40 percent addressable expansion without hardware modifications to the panel.

1.2.2 Operational Features

The system shall have the following operating features:

a. Monitor electrical supervision of IDC, SLC, and NAC, as applicable.

b. Monitor electrical supervision of the primary power (ac) supply, battery voltage, placement of alarm zone module (card, PC board) within the control panel, and transmitter tripping circuit integrity.

c. A trouble buzzer and trouble LED/LCD (light emitting diode/liquid crystal diode) to activate upon a single break, open, or ground fault condition which prevents the required normal operation of the system. The trouble signal shall also operate upon loss of primary power (ac) supply, low battery voltage, removal of alarm zone module (card, PC board), and disconnection of the circuit used for transmitting alarm signals off-premises. Submit Voltage drop calculations for notification appliance circuits to indicate that sufficient voltage is available for proper appliance operation. A trouble alarm silence switch shall be provided which will silence the trouble buzzer, but will not extinguish the trouble indicator LED/LCD. Subsequent trouble and supervisory alarms shall sound the trouble signal until silenced. After the system returns to normal operating conditions, the trouble buzzer shall again sound until the silencing switch returns to normal position, unless automatic trouble reset is provided.

d. A one person test mode. Activating an initiating device in this mode will activate an alarm for a short period of time, then automatically reset the alarm, without activating the transmitter during the entire process.

e. A transmitter disconnect switch to allow testing and maintenance of the system without activating the transmitter but providing a trouble signal when disconnected and a restoration signal when reconnected.

f. Evacuation alarm silencing switch which, when activated, will silence alarm devices, but will not affect the zone indicating LED/LCD displays on the control panel nor the operation of the transmitter. This switch shall be over-ridden upon activation of a subsequent alarm from an unalarmed device and the NAC devices will be activated.

g. Electrical supervision for circuits used for supervisory signal services (i.e., sprinkler systems, valves, etc.). Supervision shall detect any open, short, or ground.

h. Confirmation or verification of all smoke detectors. The control panel shall interrupt the transmission of an alarm signal to the system control panel for a factory preset period. This interruption period shall be adjustable from 1 to 60 seconds and be factory set at 5 seconds. Immediately following the interruption period, a confirmation period shall be in effect during which time an alarm signal, if present, will be sent immediately to the control panel. Fire alarm devices other than smoke detectors shall be programmed without confirmation or verification.

i. The fire alarm control panel shall provide supervised addressable relays for HVAC shutdown. An override at the HVAC panel shall not be provided.

j. The fire alarm control panel shall provide the required monitoring and supervised control outputs needed to accomplish elevator recall, if applicable.

k. The fire alarm control panel shall monitor and control the fire sprinkler system, or other fire protection extinguishing system.

l. The control panel and field panels shall be software reprogrammable to enable expansion or modification of the system without replacement of hardware or firmware. Examples of required changes are: adding or deleting devices or zones; changing system responses to particular input signals; programming certain input signals to activate auxiliary devices.

n. Zones for IDC and NAC shall be arranged as indicated on the contract drawings.

1.2.3 Alarm Functions

An alarm condition on a circuit shall automatically initiate the following functions:

a. Transmission of signals over the station radio fire reporting system, if applicable. The signal shall be common for any device.

b. Visual indications of the alarmed devices on the fire alarm control panel display and on the remote audible/visual display.

c. Continuous sounding or operation of alarm notification appliances throughout the building as required by ASA S3.41, unless otherwise indicated in contract drawings or other documents.

d. Closure of doors held open by electromagnetic devices.

e. Operation of the smoke control system.

f. Deactivation of the air handling units throughout the building.

g. Shutdown of power to the data processing equipment in the alarmed area.

h. Automatic discharge of fire suppression systems, if applicable. A 15 second maximum delay shall be provided deluge systems.

1.2.4 Primary Power

Operating power shall be provided as required by paragraph Power Supply for the System. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and not cause transmission of a false alarm. Loss of ac power shall not prevent transmission of a signal via the fire reporting system upon operation of any initiating circuit.

1.2.5 Battery Backup Power

Battery backup power shall be through use of rechargeable, sealed-type storage batteries and battery charger.

1.2.6 Interface With Existing Fire Alarm Equipment

For equipment to be installed as an extension to an existing configuration, submit certified copies of current approvals or listings issued by an independent test lab if not listed by UL, FM or other nationally recognized testing laboratory, showing compliance with specified NFPA standards. The new equipment shall be connected to an existing control panel in the existing part of the building or to existing monitoring equipment at the Supervising Station at building number indicated on contract drawings. Existing control or monitoring equipment shall be expanded, modified, or supplemented as necessary to extend the existing control or monitoring functions to the new points or zones. New components shall be capable of merging with the existing configuration without degrading the performance of either system. The scope of the acceptance tests of paragraph Testing shall include aspects of operation that involve combined use of both new and existing portions of the final configuration.

1.2.7 Interface With other Equipment

Interfacing components shall be furnished as required to connect to subsystems or devices which interact with the fire alarm system, such as supervisory or alarm contacts in suppression systems, operating interfaces for smoke control systems, door releases, etc.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval and information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Special Tools and Spare Parts

Battery Calculations; G

SD-06 Test Reports

Testing

SD-07 Certificates

Qualifications

SD-10 Operation and Maintenance Data

Technical Data and Computer Software
Operating and Maintenance Instructions

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Submit proof of qualifications for required personnel. The installer shall submit proof of experience for the Fire Protection Engineer, fire alarm technician, and the installing company.

1.4.1.1 Engineer and Technician

a. Registered Professional Engineer with verification of experience and at least 4 years of current experience in the design of fire protection and detection systems.

b. Level III or IV technician certified by the National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology.

c. The Registered Professional Engineer may perform all required items under this specification. The NICET Fire Alarm Technician shall perform only the items allowed by the specific category of certification held.

1.4.1.2 Installer

The installing Contractor shall provide the following: Fire Alarm Technicians to perform the installation of the system. A Fire Alarm Technician with a minimum of 4 years of experience shall perform/supervise the installation of the fire alarm system. Fire Alarm Technicians with a minimum of 2 years of experience shall be utilized to assist in the installation and terminate fire alarm devices, cabinets and panels. An electrician shall be allowed to install wire or cable and to install conduit for the fire alarm system. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.4.1.3 Fire Protection Engineer

Installations needing designs or modifications of fire detection, fire alarm, or fire suppression systems require the services and review of a qualified fire protection engineer. For the purposes of meeting this requirement, a qualified fire protection engineer is defined as an individual meeting one of the following conditions:

a. A registered professional engineer (P.E.) in fire protection engineering.

b. A registered PE in a related engineering discipline and either member grade status in the National Society of Fire Protection Engineers or a minimum of 5 years of experience dedicated to fire protection engineering that can be verified with documentation.

c. An engineer with a minimum of 10 years' experience in fire protection engineering that can be verified with documentation and member grade status in the National Society of Fire Protection Engineers.

d. Individual who is certified as a Level III or IV Technician by the National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology.

1.4.2 Detail Drawings

Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical audible appliances. Check the layout based on the actual audible devices to be installed and make any necessary revisions in the detail drawings. The detail drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Detail drawings and detailed point-to-point wiring diagram shall be prepared and signed by a Registered Professional Engineer or a NICET Level 3 or 4 Fire Alarm Technician showing points of connection. Diagram shall include connections between system devices, appliances, control panels, supervised devices, and equipment that is activated or controlled by the panel.

1.5 TECHNICAL DATA AND COMPUTER SOFTWARE

Technical data and computer software (meaning technical data which relates to computer software) which is specifically identified in this project, and which may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES, and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

a. Identification of programmable portions of system equipment and capabilities.

b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.

d. Description of Fire Alarm Control Panel equipment operation.

e. Description of auxiliary and remote equipment operations.

f. Library of application software.

g. Operation and maintenance manuals as specified in SD-10 of the Submittals paragraph.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt, dust, and any other contaminants.

1.7 SPECIAL TOOLS AND SPARE PARTS

Submit spare parts data for each different item of material and equipment specified, not later than 30 days prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies with the current unit prices and source of supply and a list of the parts recommended by the manufacturer to be replaced after 1 year of service. Furnish software, connecting cables, proprietary equipment and two spare fuses of each type and size required, necessary for the maintenance, testing, and reprogramming of the equipment. Two percent of the total number of each different type of detector, but no less than two each, shall be furnished. Mount spare fuses in the fire alarm panel.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

2.2 NAMEPLATES

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and non-heat-sensitive plate which is securely attached to the equipment.

2.3 CONTROL PANEL

Control Panel shall comply with the applicable requirements of UL 864. Panel shall be modular, installed in a flush, surface, or semi-flush mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly assembled panel containing components and equipment required to provide the specified operating and supervisory functions of the system. The panel shall have prominent rigid plastic, phenolic or metal identification plates for LED/LCDs, zones, SLC, controls, meters, fuses, and switches.

a. Nameplates for fuses shall also include ampere rating. The LED/LCD displays shall be located on the exterior of the cabinet door or be visible through the cabinet door. Control panel switches shall be within the locked cabinet. A suitable means (single operation) shall be provided for testing the control panel visual indicating devices (meters or LEDs/LCDs). Meters and LEDs shall be plainly visible when the cabinet door is closed. Signals and LEDs/LCDs shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system.

b. Each IDC shall be powered and supervised so that a signal on one zone does not prevent the receipt of signals from other devices. Loss of power, including batteries, shall not require the manual reloading of a program. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals.

c. Visual annunciation shall be provided for LED/LCD visual display as an integral part of the control panel and shall identify with a word description and id number each device. Cabinets shall be provided with ample gutter space to allow proper clearance between the cabinet and live parts of the panel equipment. If more than one modular unit is required to form a control panel, the units shall be installed in a single cabinet large enough to accommodate units. Cabinets shall be painted red or beige.

2.3.1 Remote System Audible/Visual Display

Audible appliance shall have a minimum sound level output rating of 85 dBA at 3.05 m (10 feet) and operate in conjunction with the panel integral display. The audible device shall be silenced by a system silence switch on the remote system. The audible device shall be silenced by the system silence switch located at the remote location, but shall not extinguish the visual indication. The remote LED/LCD visual display shall provide identification, consisting of the word description and id number for each device as displayed on the control panel. A rigid plastic, phenolic or metal identification sign which reads "Fire Alarm System Remote Display" shall be provided at the remote audible/visual display. The remote visual appliance located with the audible appliance shall not be extinguished until the trouble or alarm has been cleared.

2.3.2 Circuit Connections

Connect circuit conductors entering or leaving the panel to screw-type terminals with each conductor and terminal marked for identification.

2.3.3 System Expansion and Modification Capabilities

Provide, as part of this contract, any equipment and software needed by qualified technicians to implement future changes to the fire alarm system.

2.3.4 Addressable Control Module

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems, and to control door holders or initiate elevator fire service. The module shall be UL listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Class B notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled. Existing fire alarm system notification appliance circuits shall be connected to a single module to power and supervise the circuit.

2.3.5 Addressable Initiating Device Circuits Module

Configure the initiating device being monitored as a Class A initiating device circuits. The system shall be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling. The module shall be UL listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall contain an integral LED that flashes each time the monitor module is polled. Pull stations with a monitor module in a common backbox are not required to have an LED. Existing fire alarm system initiating device circuits shall be connected to a single module to power and supervise the circuit.

2.4 STORAGE BATTERIES

Submit substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component and each panel component, and the battery recharging period shall be included. Provide storage batteries which are 24 Vdc sealed, lead-calcium type requiring no additional water with ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 72 hours. Following this period of battery operation, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 15 minutes. Locate batteries at the bottom of the panel or in a separate battery cabinet. Provide batteries with overcurrent protection in accordance with NFPA 72. Separate battery cabinets shall have a lockable, hinged cover similar to the fire alarm panel. The lock shall be keyed the same as the fire alarm control panel. Paint the cabinets to match the fire alarm control panel.

2.5 BATTERY CHARGER

Battery charger shall be completely automatic, 24 Vdc with high/low charging rate, capable of restoring the batteries from full discharge (18 Volts dc) to full charge within 48 hours. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly, if a high rate switch is provided. Locate charger in control panel cabinet or in a separate battery cabinet.

2.6 ADDRESSABLE MANUAL FIRE ALARM STATIONS

Addressable manual fire alarm stations shall conform to the applicable requirements of UL 38. Manual stations shall be connected into signal line circuits. Stations shall be installed on surface, semi-flush, or flush mounted outlet boxes as indicated. Manual stations shall be mounted at 1220 mm (48 inches). Stations shall be single or double action type. Stations shall be finished in red, with raised letter operating instructions of contrasting color. Stations requiring the breaking of glass or plastic panels for operation are not acceptable. Stations employing glass rods are not acceptable. The use of a key or wrench shall be required to reset the station. Gravity or mercury switches are not acceptable. Switches and contacts shall be rated for the voltage and current upon which they operate. Addressable pull stations shall be capable of being field programmed, shall latch upon operation and remain latched until manually reset. Stations shall have a separate screw terminal for each conductor. Surface mounted boxes shall be matched and painted the same color as the fire alarm manual stations.

2.7 FIRE DETECTING DEVICES

Fire detecting devices shall comply with the applicable requirements of NFPA 72, NFPA 90A, UL 268, UL 268A, and UL 521. The detectors shall be provided as indicated. Detector base shall have screw terminals for making connections. No solder connections will be allowed. Detectors located in concealed locations (above ceiling, raised floors, etc.) shall have a remote visible indicator LED/LCD. Addressable fire detecting devices, except flame detectors, shall be dynamically supervised and uniquely identified in the control panel. All fire alarm initiating devices shall be individually addressable, except where indicated. Installed devices shall conform to NFPA 70 hazard classification of the area where devices are to be installed.

2.7.1 Heat Detectors

Design heat detectors for detection of fire by fixed temperature, combination fixed temperature and rate-of-rise principle, or rate-compensating principle as indicated. Heat detector spacing shall be rated in accordance with UL 521. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70 and as shown on drawings, shall be types approved for such locations. Heat detectors located in attic spaces or similar concealed spaces below the roof shall be intermediate temperature rated.

2.7.1.1 Combination Fixed-Temperature and Rate-of-Rise Detectors

Detectors shall be designed for surface or semi-flush outlet box mounting and supported independently of wiring connections. Contacts shall be self-resetting after response to rate-of-rise principle. Under fixed temperature actuation, the detector shall have a permanent external indication which is readily visible. Detector units located in boiler rooms, showers, or other areas subject to abnormal temperature changes shall operate on fixed temperature principle only. The UL 521 test rating for the fixed temperature portion shall be as shown. The UL 521 test rating for the Rate-of-Rise detectors shall be rated for 15 by 15 m (50 by 50 ft).

2.7.1.2 Rate Compensating Detectors

Detectors shall be surface or flush mounted vertical or horizontal type, with outlet box supported independently of wiring connections. Detectors shall be hermetically sealed and automatically resetting. Rate Compensated detectors shall be rated for 15 by 15 m (50 by 50 ft).

2.7.1.3 Fixed Temperature Detectors

Detectors shall be designed for surface or semi-flush outlet box mounting and supported independently of wiring connections. Detectors shall be designed to detect high heat. The detectors shall have a specific temperature setting as shown. The UL 521 test rating for the fixed temperature detectors shall be rated for 4.57 by 4.57 m (15 by 15 ft).

2.7.2 Smoke Detectors

Design smoke detectors for detection of abnormal smoke densities. Smoke detectors shall be photoelectric or projected beam type. Detectors shall contain a visible indicator LED/LCD that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Detectors shall be the plug-in type in which the detector base contains terminals for making wiring connections. Detectors that are to be installed in concealed (above false ceilings, etc.) locations shall be provided with a remote indicator LED/LCD suitable for mounting in a finished, visible location.

2.7.2.1 Photoelectric Detectors

Detectors shall operate on a light scattering concept using an LED light source. Failure of the LED shall not cause an alarm condition. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind. Detectors shall have an obscuration rating in accordance with UL 268. Addressable smoke detectors shall be capable of having the sensitivity being remotely adjusted by the control panel.

2.7.2.2 Projected Beam Smoke Detectors

Detectors shall be designed for detection of abnormal smoke densities. Detectors shall consist of separate transmitter and receiver units. The transmitter unit shall emit an infrared beam to the receiver unit. When the signal at the receiver falls below a preset sensitivity, the detector shall initiate an alarm. The receiver shall contain an LED which is powered upon an alarm condition. Long-term changes to the received signal caused by environmental variations shall be automatically compensated. Detectors shall incorporate features to assure that they are operational; a trouble signal shall be initiated if the beam is obstructed, the limits of the compensation circuit are reached, or the housing cover is removed. Detectors shall have multiple sensitivity settings in order to meet UL listings for the different distances covered by the beam. In the event of beam interference for more than three seconds a trouble alarm shall be transmitted.

2.7.2.3 Duct Detectors

Duct-mounted photoelectric smoke detectors shall be furnished and installed where indicated and in accordance with NFPA 90A. Units shall consist of a smoke detector as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have a manual reset. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s (500 and 4000) fpm). Detectors shall be powered from the fire alarm panel. Sampling tubes shall run the full width of the duct. The duct detector package shall conform to the requirements of NFPA 90A, UL 268A, and shall be UL listed for use in air-handling systems. The control functions, operation, reset, and bypass shall be controlled from the fire alarm control panel. Lights to indicate the operation and alarm condition; and the test and reset buttons shall be visible and accessible with the unit installed and the cover in place. Detectors mounted above 1.83 m (6 feet) and those mounted below 1.83 m (6 feet) that cannot be easily accessed while standing on the floor, shall be provided with a remote detector indicator panel containing test and reset switches. Remote lamps and switches as well as the affected fan units shall be properly identified in etched plastic placards. Detectors shall have auxiliary contacts to provide control, interlock, and shutdown functions specified in Section 23 09 23 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS. The detectors shall be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.7.3 Combination Smoke and Heat Detectors

Combination smoke and heat detectors shall have an audible device (self-contained) and be designed for detection of abnormal smoke densities by the photoelectric principle and abnormal heat by a fixed temperature sensor. Smoke detectors shall be provided with an LED light source. Failure of the LED shall not cause an alarm condition and the sensitivity shall be factory set at a nominal 3 percent and require no field adjustments of any kind. Heat detector portion shall be fixed temperature sensor rated at 57 degrees C (135 degrees F). The audible appliances shall have a minimum sound output of at least 85 dBA at 3.05 m (10 feet). Detectors shall contain a visible indicator LED that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Heat detectors shall connect to a control panel SLC or IDC and shall be self restorable.

2.7.4 Flame Detectors

The detectors shall comply with FM APP GUIDE. The detectors shall be sensitive to the micron range best suited for their intended use. The detectors shall operate over electrically supervised wiring circuits and the loss of power to the detector shall result in a trouble signal. A self-test feature shall be provided for each detector to be individually tested.

2.7.4.1 Infrared (IR) Single Frequency Flame Detector

The detector shall be sensitive in the range as indicated on contract drawings.

2.7.4.2 Infrared (IR) Dual Frequency Flame Detector

The IR detector shall consist of two or more IR sensors, each selected for a different IR frequency. The primary sensor shall be sensitive in the range as indicated on contract drawings. Secondary sensors are tuned to different IR wavelengths to null out the effect of black body radiation to the primary sensor.

2.7.4.3 Ultraviolet (UV) Flame Detectors

UV flame detector shall be of the narrow band response type which operates on radiated ultraviolet energy and shall be sensitive in the range as indicated on contract drawings. The cone of vision shall be 80 degrees or greater. Each detector shall be completely insensitive to light sources in the visible frequency range.

2.7.4.4 Combination UV/IR Flame Detector

The UV/IR detector shall provide discrimination against false alarms by requiring both UV and IR flame detection before an alarm is sent. The UV sensor shall be sensitive in the range of 0.185 to 0.265 micrometers only. The IR sensor shall be sensitive in the range as indicated on contract drawings. Detectors shall be completely insensitive to light sources in the visible frequency range.

2.8 NOTIFICATION APPLIANCES

Audible appliances shall conform to the applicable requirements of UL 464. Devices shall be connected into notification appliance circuits. Devices shall have a separate screw terminal for each conductor. Audible appliances shall generate a unique audible sound from other devices provided in the building and surrounding area. Surface mounted audible appliances shall be painted red. Recessed audible appliances shall be installed with a grill that is painted red.

2.8.1 Alarm Bells

Bells shall be surface mounted with the matching mounting back box surface mounted or recessed. Bells shall be suitable for use in an electrically supervised circuit. Bells shall be the underdome type producing a minimum output rating of 85 dBA at 3.1 m (10 feet). Bells used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles. Single stroke, electrically operated, supervised, solenoid bells shall be used for coded applications.

2.8.2 Alarm Horns

Horns shall be surface mounted, with the matching mounting back box surface mounted or recessed single projector, grille and vibrating type suitable for use in an electrically supervised circuit. Horns shall produce a sound rating of at least 85 dBA at 3.05 m (10 feet). Horns used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles.

2.8.3 Chimes

Chimes shall be electrically operated, supervised, electronic type, with an adjustable frequency of 800 to 1200 Hertz. Chimes shall have a minimum sound rating of 80 dBA at 3.05 m (10 feet). Chimes shall ring the bell codes, as indicated.

2.8.4 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and the contract drawings. Appliances shall have clear high intensity optic lens, xenon flash tubes, and output white light. Strobe flash rate shall be between 1 to 3 flashes per second and a minimum of 75 candela. Strobe shall be surface or semi-flush mounted.

2.8.5 Combination Audible/Visual Notification Appliances

Combination audible/visual notification appliances shall provide the same requirements as individual units except they shall mount as a unit in standard backboxes. Units shall be factory assembled. Any other audible notification appliance employed in the fire alarm systems shall be approved by the Contracting Officer.

2.8.6 Voice Evacuation System

Voice evacuation systems shall provide for one-way voice communications, routing and pre-amplification of digital alarm tones and voice (digital and analog) messages. The system shall be zoned for messages (Custom and prerecorded) and tones as indicated on the drawings. The following electronic tones shall be available from the amplifier: Slow Whoop, High/Low, Horn, Chime, Beep, Stutter, Wail and Bell. The system shall have a microphone and allow for general paging within the space. Operation shall be either manually from a control switch or automatically from the fire alarm control panel. Reset shall be accomplished by the fire alarm control panel during panel reset.

2.9 FIRE DETECTION AND ALARM SYSTEM PERIPHERAL EQUIPMENT

2.9.1 Electromagnetic Door Hold-Open Devices

Devices shall be attached to the walls unless otherwise indicated. Devices shall comply with the appropriate requirements of UL 228. Devices shall operate on 24 Volt dc power. Compatible magnetic component shall be attached to the door. Under normal conditions, the magnets shall attract and hold the doors open. When magnets are de-energized, they shall release the doors. Magnets shall have a holding force of 111.2 N (25 pounds). Devices shall be UL or FM approved. Housing for devices shall be brushed aluminum or stainless steel. Operation shall be fail safe with no moving parts. Electromagnetic door hold-open devices shall not be required to be held open during building power failure.

2.9.2 Conduit

Conduit and fittings shall comply with NFPA 70, UL 6, UL 1242, and UL 797 or KS C 8401, KS C 8422, KS C 8431, KS C 8458, KS C 8459, KS C 8460, and KS C 8461.

2.9.3 Wiring

Wiring shall conform to NFPA 70. Wiring for 120 Vac power shall be No. 12 AWG minimum. The SLC wiring shall be fiber optic or copper cable in accordance with the manufacturer's requirements. Wiring for fire alarm dc circuits shall be No. 14 AWG minimum. Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Wiring shall conform to NFPA 70. System field wiring shall be solid copper and installed in rigid metallic conduit or electrical metallic tubing, except that rigid plastic conduit may be used under slab-on-grade. Conductors shall be color coded. Conductors used for the same functions shall be similarly color coded. Wiring code color shall remain uniform throughout the circuit. Pigtail or T-tap connections to initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. T-tapping using screw terminal blocks is allowed for style 5 addressable systems.

2.10 TRANSMITTERS (TRANSCEIVERS)

2.10.1 Radio Alarm Transmitters (Transceivers)

Transmitters (transceivers)shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters (transceivers) shall be provided in accordance with applicable portions of NFPA 72, NFPA 1221, and 47 CFR 15. Transmitter (transceiver) electronics module shall be contained within the physical housing as an integral, removable assembly. The transceiver shall be fully compatible with existing proprietary supervising station receiving equipment. At the Contractors option, and if UL listed, the transmitter (transceiver) may be housed in the same panel as the fire alarm control panel.

2.10.1.1 Transmitter (Transceiver) Power Supply

Each radio alarm transmitter (transceiver) shall be powered by a combination of locally available 120-volt ac power and a sealed, lead-calcium battery.

a. Operation: Each transmitter (transceiver) shall operate from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter (transceiver) shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

b. Battery Power: Transmitter (transceiver) standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

2.10.1.2 Radio Alarm Transmitter (Transceiver) Housing

Transmitter (transceiver) housing shall be NEMA Type 1. The housing shall contain a lock that is keyed identical to radio alarm transmitter (transceiver) housings on the base. Radio alarm transmitter (transceiver) housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.10.1.3 Antenna

Provide omnidirectional, coaxial, halfwave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall be corrosion resistant and designed to withstand wind velocities of 161 km/h (100 mph). Antennas shall not be mounted to any portion of the building roofing system.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install all work as shown, in accordance with NFPA 70 and NFPA 72, and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified. Smoke detectors shall not be installed until construction is essentially complete and the building has been thoroughly cleaned.

3.2.1 Power Supply for the System

Provide a single dedicated circuit connection for supplying power from a branch circuit to each building fire alarm system. The power shall be supplied as shown on the drawings. The power supply shall be equipped with a locking mechanism and marked in red with the words "FIRE ALARM CIRCUIT CONTROL".

3.2.2 Wiring

Conduit size for wiring shall be in accordance with NFPA 70. Wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. Not more than two conductors shall be installed under any device screw terminal. The wires under the screw terminal shall be straight when placed under the terminal then clamped in place under the screw terminal. The wires shall be broken and not twisted around the terminal. Circuit conductors entering or leaving any mounting box, outlet box enclosure, or cabinet shall be connected to screw terminals with each terminal and conductor marked in accordance with the wiring diagram. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors in the system is prohibited. Wiring within any control equipment shall be readily accessible without removing any component parts.The fire alarm equipment manufacturer's representative shall be present for the connection of wiring to the control panel.

3.2.3 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 300 mm (12 inches) nor more than 2000 mm (78 inches) above the finished floor. Manually operable controls shall be between 900 and 1100 mm (36 and 42 inches) above the finished floor. Panel shall be installed to comply with the requirements of UL 864.

3.2.4 Detectors

Detectors shall be located and installed in accordance with NFPA 72. Detectors shall be connected into signaling line circuits or initiating device circuits as indicated on the drawings. Detectors shall be at least 300 mm (12 inches) from any part of any lighting fixture. Detectors shall be located at least 900 mm (3 feet) from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in open space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds 900 mm (3 feet), sway bracing shall be provided. Detectors installed in concealed locations (above ceiling, raised floors, etc.) shall have a remote visible indicator LED/LCD in a finished, visible location or as indicated.

3.2.5 Notification Appliances

Notification appliances shall be mounted 2003 mm (80 inches) above the finished floor or 150 mm (6 inches) below the ceiling, whichever is lower.

3.2.6 Annunciator Equipment

Annunciator equipment shall be mounted where indicated on the drawings.

3.2.7 Addressable Initiating Device Circuits Module

The initiating device circuits module shall be used to connect supervised conventional initiating devices (water flow switches, water pressure switches, manual fire alarm stations, high/low air pressure switches, and tamper switches). The module shall mount in an electrical box adjacent to or connected to the device it is monitoring and shall be capable of Style B supervised wiring to the initiating device. In order to maintain proper supervision, there shall be no T-taps allowed on style B lines. Addressable initiating device circuits modules shall monitor only one initiating device each. Contacts in suppression systems and other fire protection subsystems shall be connected to the fire alarm system to perform supervisory and alarm functions as specified in Section 21 13 13.00 10 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION, 21 13 17.00 10 DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION, 21 13 18.00 10 PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION and NFPA 72, as indicated on the drawings and as specified herein.

3.2.8 Addressable Control Module

Addressable and control modules shall be installed in the outlet box or adjacent to the device they are controlling. If a supplementary suppression releasing panel is provided, then the monitor modules shall he mounted in a common enclosure adjacent to the suppression releasing panel and both this enclosure and the suppression releasing panel shall be in the same room as the releasing devices. All interconnecting wires shall be supervised unless an open circuit or short circuit abnormal condition does not affect the required operation of the fire alarm system. If control modules are used as interfaces to other systems, such as HVAC or elevator control, they shall be within the control panel or immediately adjacent to it. Control modules that control a group of notification appliances shall be adjacent to the first notification appliance in the notification appliance circuits. Control modules that connect to devices shall supervise the notification appliance circuits. Control modules that connect to auxiliary systems or interface with other systems (non-life safety systems) and where not required by NFPA 72, shall not require the secondary circuits to be supervised. Contacts in suppression systems and other fire protection subsystems shall be connected to the fire alarm system to perform required alarm functions as specified in Section 21 13 13.00 10 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION, 21 13 17.00 10 DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION, 21 13 18.00 10 PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION, and NFPA 72, as indicated on the drawings and as specified herein.

3.3 OVERVOLTAGE AND SURGE PROTECTION

3.3.1 Power Line Surge Protection

All equipment connected to alternating current circuits shall be protected from surges in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground).

3.3.2 Low Voltage DC Circuits Surge Protection

All IDC, NAC, and communication cables/conductors, except fiber optics, shall have surge protection installed at each point where it exits or enters a building. Equipment shall be protected from surges in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. The surge protector shall be rated to protect the 24 Volt dc equipment. The maximum dc clamping voltages shall be 36 V (line-to-ground) and 72 Volt dc (line-to-line).

3.3.3 Signal Line Circuit Surge Protection

All SLC cables/conductors, except fiber optics, shall have surge protection/isolation circuits installed at each point where it exits or enters a building. The circuit shall be protected from surges in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. The surge protector/isolator shall be rated to protect the equipment.

3.4 GROUNDING

Grounding shall be provided by connecting to building ground system.

3.5 SUPERVISING STATION PROVISIONS

3.5.1 Revisions to Existing Facilities

Existing supervising components shall be modified as indicated on the drawings and programming shall be updated if required to accommodate the revised configuration. Acceptance testing shall include procedures that would demonstrate that operation of existing equipment has not been degraded and that the revised configuration plus interfacing components operates compatibly with the new fire alarm system at the protected premises. Work on existing equipment shall be performed in accordance with the manufacturer's instructions or under supervision of the manufacturer's representative.

3.5.2 Additions to Existing Facilities

Supplemental components shall be added to the existing supervising equipment as required to accommodate the new fire alarm system to be installed at the protected premises as indicated on the drawings. All present functions shall be extended, including recording and storage in memory, and programming shall be updated if required to accommodate the revised configuration. Acceptance testing shall include procedures that would demonstrate that operation of existing equipment has not been degraded and that the expanded configuration operates compatibly with the new fire alarm system.

3.6 TRAINING

Submit lesson plans, operating instructions, maintenance procedures, and training data, furnished in manual format, for the training courses. The operations training shall familiarize designated government personnel with proper operation of the fire alarm system. Conduct the course in the building where the system is installed or as designated by the Contracting Officer.

a. The instructions shall cover items contained in the operating and maintenance instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of operating and maintenance instructions listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to training. In addition, training shall be provided on performance of expansions or modifications to the fire detection and alarm system. The training period for system expansions and modifications shall consist of at least 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests.

b. The maintenance training course shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system. Provide training course for the maintenance staff. The training period for systems maintenance shall consist of 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests. Six copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements. Original and backup copies of all software delivered for this project shall be provided, on each type of media utilized. Manuals shall be approved prior to training.

c. The training period for systems operation shall consist of 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests. Six copies of operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features.

3.7 TESTING

Notify the Contracting Officer at least 10 days before the preliminary and acceptance tests are to be conducted. Perform the tests in accordance with the approved test procedures in the presence of the Contracting Officer. The control panel manufacturer's representative shall be present to supervise tests. Furnish instruments and personnel required for the tests.

a. Submit detailed test procedures, prepared and signed by a Registered Professional Engineer or a NICET Level 3 or 4 Fire Alarm Technician, for the fire detection and alarm system 30 days prior to performing system tests.

b. Submit test reports, one hard copy and one digital copy (.pdf - text searchable), showing field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document readings, test results and indicate the final position of controls. Include the NFPA 72 Certificate of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

3.7.1 Preliminary Tests

Upon completion of the installation, subject the system to functional and operational performance tests including tests of each installed initiating and notification appliance, when required. Tests shall include the meggering of system conductors to determine that the system is free from grounded, shorted, or open circuits. Conduct the megger test prior to the installation of fire alarm equipment. If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional. After completing the preliminary testing complete and submit the NFPA 72, Certificate of Completion and Testing Form.

3.7.2 Acceptance Test

Acceptance testing shall not be performed until the Contractor has completed and submitted the Certificate of Completion. Conduct testing in accordance with NFPA 72. The recommended tests in NFPA 72 are considered mandatory and shall verify that previous deficiencies have been corrected. The Fire alarm Technician supervising the installation of the fire alarm system shall attend the testing of the system. The test shall include all requirements of NFPA 72 and the following:

a. Test of each function of the control panel.

b. Test of each circuit in both trouble and normal modes.

c. Tests of each alarm initiating devices in both normal and trouble conditions.

d. Tests of each control circuit and device.

e. Tests of each alarm notification appliance.

f. Tests of the battery charger and batteries.

g. Complete operational tests under emergency power supply.

h. Visual inspection of wiring connections.

i. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.

j. Ground fault.

k. Short circuit faults.

l. Stray voltage.

m. Loop resistance.

-- End of Section --

SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM
08/11

PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 21 30 00 FIRE PUMPS
Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS
Section 21 13 13.00 10 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
Section 21 13 17.00 10 DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION
Section 21 13 18.00 10 PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION
Section 21 13 24.00 10 AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM
Section 21 21 03.00 10 WET CHEMICAL FIRE EXTINGUISHING SYSTEM
Section 08 71 00 DOOR HARDWARE for door release and door unlocking and additional work related to finish hardware.
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2	(2009) Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ASME INTERNATIONAL (ASME)

ASME A17.1/CSA B44	(2010) Safety Code for Elevators and Escalators

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60268-16	(2003) Sound System Equipment - Part 16: Objective Rating Of Speech Intelligibility By Speech Transmission Index; Ed 3.0

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 7240-16	(2007) Fire Detection And Alarm Systems — Part 16: Sound System Control And Indicating Equipment
ISO 7240-19	(2007) Fire Detection and Alarm Systems — Part 19: Design, Installation, Commissioning and Service of Sound Systems for Emergency Purposes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 170	(2012) Standard for Fire Safety and Emergency Symbols
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-601-02	(2010) Operations and Maintenance: Inspection, Testing, and Maintenance of Fire Protection Systems
UFC 4-021-01	(2008; Change 1 2010) Design and O&M: Mass Notification Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices
47 CFR 90	Private Land Mobile Radio Services

UNDERWRITERS LABORATORIES (UL)

UL 1480	(2003; Reprint Jun 2010) Standard for Speakers for Fire Alarm, Emergency, and Commercial and Professional Use
UL 1638	(2001; Reprint Oct 2008) Visual Signaling

	Appliances - Private Mode Emergency and General Utility Signaling
UL 1971	(2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
UL 2017	(2008; Reprint May 2011) General-Purpose Signaling Devices and Systems
UL 268	(2009) Smoke Detectors for Fire Alarm Systems
UL 464	(2009; Reprint Apr 2012) Standard for Audible Signal Appliances
UL 521	(1999; Reprint May 2010) Heat Detectors for Fire Protective Signaling Systems
UL 864	(2003; Reprint Aug 2012) Standard for Control Units and Accessories for Fire Alarm Systems
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.3 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions shall be defined as follows:

a. Interface Device: An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

b. Remote Fire Alarm and Mass Notification Control Unit: A control panel, electronically remote from the fire alarm and mass notification control panel, that receives inputs from automatic and manual fire alarm devices; may supply power to detection devices and interface devices; may provide transfer of power to the notification appliances; may provide transfer of condition to relays or devices connected to the control unit; and reports to and receives signals from the fire alarm control panel.

c. Fire Alarm Control Unit and Mass Notification Autonomous Control Unit (FMCP): A master control panel having the features of a fire alarm and mass notification control unit and fire alarm and mass notification control units are interconnected. The panel has central processing, memory, input and output terminals, and LCD, LED Display units.

d. Local Operating Console (LOC): A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery or recorded and/or live messages, initiate strobe and textural visible appliance operation and other relayed functions.

e. Terminal Cabinet: A steel cabinet with locking, hinge-mounted door that terminal strips are securely mounted.

1.4 SYSTEM DESCRIPTION

1.4.1 Scope

a. This work includes completion of design and providing a new, complete, and modifying the existing fire alarm and mass notification system as described herein and on contract drawings. Include in the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, alarm, and supervisory signal initiating devices, alarm notification appliances, supervising station fire alarm system transmitter, and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation.

b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with the required and advisory provisions of NFPA 72, ISO 7240-16, IEC 60268-16, except as modified herein. The system layout on the drawings shows the intent of coverage and devices are shown in suggested locations. Submit plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, wire counts, circuit identification in each conduit, and circuit layouts for all floors. Drawings shall comply with the requirements of NFPA 170. Final quantity, system layout, and coordination are the responsibility of the Contractor.

c. Where remote fire alarm control units are needed, they shall be provided at a terminal cabinet location. Each remote fire alarm control unit shall be powered from a wiring riser specifically for that use or from a local emergency power panel located on the same floor as the remote fire alarm control unit. Where remote fire control units are provided, equipment for notification appliances may be located in the remote fire alarm control units.

1.4.2 Technical Data and Computer Software

Technical data and computer software (meaning technical data that relates to computer software) that is specifically identified in this project, and may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES. Identify data delivered by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

a. Identification of programmable portions of system equipment and capabilities.

b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.

d. Description of Fire Alarm and Mass Notification Control Panel equipment operation.

e. Description of auxiliary and remote equipment operations.

f. Library of application software.

g. Operation and maintenance manuals.

1.4.3 Keys

Keys and locks for equipment shall be identical. Provide not less than six keys of each type required. Master all keys and locks to a single key as required by the Installation Fire Department. Keys shall be CAT 60. LOC is not permitted to be locked or lockable.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval and information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Wiring Diagrams; G
System Layout; G
System Operation; G

SD-03 Product Data

Fire Alarm Control Unit and Mass Notification Control Unit (FMCP); G
Manual stationsTransmitters (including housing); G
Batteries; G
Battery chargers; G
Smoke sensors
Heat detectors
Notification appliances
Addressable interface devices
Amplifiers
Remote Fire Alarm/Mass Notification Control Units; G
Radio transmitter and interface panels
Local Operating Console (LOC)

SD-05 Design Data

Battery Power Calculations

SD-06 Test Reports

Field Quality Control
Testing Procedures
Final Testing

SD-07 Certificates

Qualifications

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions

Instruction of Government Employees

SD-11 Closeout Submittals

As-Built Drawings
Technical Data And Computer Software

1.6 QUALITY ASSURANCE

Equipment and devices shall be compatible and operable with existing station fire alarm system and shall not impair reliability or operational functions of existing supervising station fire alarm system.

a. In NFPA publications referred to herein, consider advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears; interpret reference to "authority having jurisdiction" to mean the Contracting Offices Designated Representative (COR).

b. The recommended practices stated in the manufacturer's literature or documentation shall be considered as mandatory requirements.

c. Devices and equipment for fire alarm service shall be listed by UL Fire Prot Dir or approved by FM APP GUIDE.

1.6.1 Qualifications

Submit proof of qualifications for required personnel. The contractor shall submit proof of experience for the Fire Protection Engineer, Supervisor, Technician, Installer, and Test Personnel.

1.6.1.1 Fire Protection Engineer

Installations requiring completion of installation drawings and specification or modifications of fire detection, fire alarm, mass notification system, fire suppression systems or mass notification systems shall require the services and review of a qualified fire protection engineer. For the purposes of meeting this requirement, a qualified fire protection engineer is defined as an individual meeting one of the following conditions:

a. A registered professional engineer (P.E.) in fire protection engineering.

b. A registered PE in a related engineering discipline and either member grade status in the National Society of Fire Protection Engineers or a minimum of 5 years of experience dedicated to fire protection engineering that can be verified with documentation.

c. An engineer with a minimum of 10 years' experience in fire protection engineering that can be verified with documentation and member grade status in the National Society of Fire Protection Engineers.

d. Individual who is certified as a Level III or IV Technician by the National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology.

1.6.1.2 Supervisor

A Fire Alarm Technician with a minimum of 8 years of experience shall perform/supervise the installation of the fire alarm/mass notification system. The Fire Alarm technicians supervising the installation of equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.3 Technician

Fire Alarm Technicians with a minimum of four years of experience shall be utilized to install and terminate fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.4 Installer

Fire Alarm installer with a minimum of two years of experience utilized to assist in the installation of fire alarm/mass notification devices, cabinets and panels. An electrician shall be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. The Fire Alarm installer shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.5 Test Personnel

Fire Alarm Technicians with a minimum of eight years of experience and current National Institute for Certification in Engineering Technologies (NICET) Level III or IV certification in the Fire Alarm Systems subfield of Fire Protection Engineering Technology shall be utilized to test and certify the installation of the fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians testing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.6 Manufacturer

Components shall be of current design and shall be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as otherwise or additionally specified herein.

1.6.2 Regulatory Requirements

1.6.2.1 Requirements for Fire Protection Service

Equipment and material shall have been tested by UL and listed in UL Fire Prot Dir or approved by FM and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, they shall mean listed in UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement. All listings or approval by testing laboratories shall be from an existing ANSI or UL published standard.

1.6.2.2 Fire Alarm/Mass Notification System

Furnish equipment that is compatible and is UL listed, FM approved, or listed by a nationally recognized testing laboratory for the intended use. All listings by testing laboratories shall be from an existing ANSI or UL published standard. Submit a unique identifier for each device, including the control panel and initiating and indicating devices, with an indication of test results, and signature of the factory-trained technician of the control panel manufacturer and equipment installer. With reports on preliminary tests, include printer information. Include the NFPA 72 Record of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

1.6.2.3 Fire Alarm Testing Services or Laboratories

Construct fire alarm and fire detection equipment in accordance with UL Fire Prot Dir, UL Electrical Constructn, or FM APP GUIDE.

1.7 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit one hard copy and one digital copy (.pdf - text searchable, if scanning documents, use Optical Character Recognition (OCR)) of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions shall be a single volume or in separate volumes, and may be submitted as a Technical Data Package. Manuals shall be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions shall include:

a. "Manufacturer Data Package 5" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

b. Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features.

c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.

d. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements.

e. Software delivered for this project shall be provided, on each type of CD/DVD media utilized.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference. All data (devices, testing frequencies, etc.) shall comply with UFC 3-601-02.

1.9 EXTRA MATERIALS

1.9.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system shall be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During guarantee period, the service technician shall be on-site within 24 hours after notification. All repairs shall be completed within 24 hours of arrival on-site.

1.9.2 Interchangeable Parts

Spare parts furnished shall be directly interchangeable with the corresponding components of the installed system. Spare parts shall be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts shall be delivered to the Contracting Officer at the time of the final acceptance testing.

1.9.3 Spare Parts

Furnish the following spare parts and accessories:

a. Four fuses for each fused circuit

b. Two of each type of notification appliance in the system (e.g. speaker, FA strobe, MNS strobe, etc.)

c. Two of each type of initiating device included in the system (e.g. smoke detector, thermal detector, manual station, etc.)

1.9.4 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment shall be furnished to the Contracting Officer.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Submit annotated catalog data as required in the paragraph SUBMITTAL, in table format on the drawings, showing manufacturer's name, model, voltage, and catalog numbers for equipment and components. Submitted shop drawings shall not be smaller than ISO A1. Also provide UL or FM listing cards for equipment provided.

2.1.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory, such as UL or FM Approvals, LLC (FM), and listed or approved for fire protection service when so required by NFPA 72 or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least two years prior to bid opening.

2.1.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

a. FMCPs

b. Automatic transmitter/transceiver

c. Terminal Cabinet

Furnish nameplate illustrations and data to obtain approval by the Contracting Officer before installation. Obtain approval by the Contracting Officer for installation locations. Nameplates shall be etched metal or plastic, permanently attached by screws to panels or adjacent walls.

2.2 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment shall be listed for use under the applicable reference standards. Interfacing of Listed UL 864 or similar approved industry listing with Mass Notification Panels listed to UL 2017 shall be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control. If a field modification is needed, such as adding equipment like relays, the manufacturer of the panels being same or different brand from manufacturer shall provide the installing contractor for review and confirmation by the installing contractor. As part of the submittal documents, provide this information.

2.3 SYSTEM OPERATION

The Addressable Interior Fire Alarm and Mass Notification System shall be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864 , and UL 2017. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until the initiating device is reset and the control panel is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, or remotely from authorized locations/users.

Submit data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances, 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings. Submit a complete description of the system operation in matrix format on the drawings. Submit a complete list of device addresses and corresponding messages.

2.3.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice, Textural)

a. Connect alarm initiating devices to initiating device circuits (IDC) Class "A", or to signal line circuits (SLC) Class "A" and installed in accordance with NFPA 72.

b. Connect alarm notification appliances and speakers to notification appliance circuits (NAC) Class "A.

c. The system shall operate in the alarm mode upon actuation of any alarm initiating device or a mass notification signal. The system shall remain in the alarm mode until initiating device(s) or mass notification signal is/are reset and the control panel is manually reset and restored to normal. Audible, and visual appliances and systems shall comply with NFPA 72 and as specified herein. Fire alarm system/mass notification system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc.

2.3.2 Functions and Operating Features

The system shall provide the following functions and operating features:

a. The FMCP shall provide power, annunciation, supervision, and control for the system. Addressable systems shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.

b. For Class "A" or "X" circuits with conductor lengths of 3m (10 feet) or less, the conductors shall be permitted to be installed in the same raceway in accordance with NFPA 72.

c. Provide signaling line circuits for each floor.

d. Provide signaling line circuits for the network.

e. Provide notification appliance circuits. The visual alarm notification appliances shall have the flash rates synchronized as required by NFPA 72.

f. Provide electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control panel.

g. Provide an audible and visual trouble signal to activate upon a single break or open condition, or ground fault (or short circuit for Class "X"). The trouble signal shall also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory panel modules. Provide a trouble alarm silence feature that shall silence the audible trouble signal, without affecting the visual indicator. After the system returns to normal operating conditions, the trouble signal shall again sound until the trouble is acknowledged. A smoke sensor in the process of being verified for the actual presence of smoke shall not initiate a trouble condition.

h. Provide program capability via switches in a locked portion of the FACP to bypass the automatic notification appliance circuits, fire reporting system, air handler shutdown, smoke control operation, elevator recall, door release, door unlocking features. Operation of this programming shall indicate this action on the FACP display and printer output.

i. Alarm, supervisory, and/or trouble signals shall be automatically transmitted to the fire department.

j. Alarm functions shall override trouble or supervisory functions. Supervisory functions shall override trouble functions.

k. The system shall be capable of being programmed from the panel's keyboard. Programmed information shall be stored in non-volatile memory.

l. The system shall be capable of operating, supervising, and/or monitoring both addressable and non-addressable alarm and supervisory devices.

m. There shall be no limit, other than maximum system capacity, as to the number of addressable devices that may be in alarm simultaneously.

n. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system, such as an HVAC system, an atrium exhaust system, a smoke control system, an elevator system, or a releasing panel, the addressable fire alarm relay shall be in the vicinity of the emergency control device.

o. An alarm signal shall automatically initiate the following functions:

(1) Transmission of an alarm signal to the fire department.

(2) Visual indication of the device operated on the control panel (FACP/MNCP), LCD, LED Display unit (VDU), and on the graphic annunciator. Indication on the graphic annunciator shall be by floor, zone or circuit, and type of device.

(3) Continuous actuation of all alarm notification appliances.

(4) Recording of the event via electronically in the history log of the fire control system unit.

(5) Release of doors held open by electromagnetic devices.

(6) Operation of the smoke control system and atrium exhaust system.

(7) Release of power to electric locks (delayed egress locks) on doors that are part of the means of egress.

(8) Operation of a smoke sensor in an elevator lobby or other location associated with the automatic recall of elevators, shall recall the elevators in addition to other requirements of this paragraph.

(9) Operation of a duct smoke sensor shall shut down the appropriate air handler in accordance with NFPA 90A in addition to other requirements of this paragraph and as allowed by NFPA 72.

(10) Operation of fire alarm shall release the fire extinguishing system after time delay as indicated on contract drawings.

(11) Operation of a sprinkler waterflow switch serving an elevator machinery room or elevator shaft shall operate shunt trip circuit breaker(s) to shut down power to the elevators in accordance with ASME A17.1/CSA B44.

(12) Operation of an interface, that operates vibrating pagers worn by hearing-impaired occupants.

p. A supervisory signal shall automatically initiate the following functions:

(1) Visual indication of the device operated on the FACP, VDU, and on the graphic annunciator, and sound the audible alarm at the respective panel.

(2) Transmission of a supervisory signal to the fire department.

(3) Recording of the event electronically in the history log of the control unit.

q. A trouble condition shall automatically initiate the following functions:

(1) Visual indication of the system trouble on the FACP, VDU, and on the graphic annunciator, and sound the audible alarm at the respective panel.

(2) Transmission of a trouble signal to the fire department.

(3) Recording of the event in the history log of the control unit.

r. The maximum permissible elapsed time between the actuation of an initiating device and its indication at the FACP is 10 seconds.

s. The maximum elapsed time between the occurrence of the trouble condition and its indication at the FACP is 200 seconds.

t. Activation of a LOC pushbutton shall activate the audible and visual alarms in the facility. The audible message shall be the one associated with the pushbutton activated.

2.4 SYSTEM MONITORING

2.4.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, standpipe control valves, sprinkler service entrance valve, valves at fire pumps, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, shall be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address, unless they are within the same room, then a maximum of five can use the same address.

2.4.2 Independent Fire Detection System

Each existing independent smoke detection subsystem, kitchen fire extinguishing system, and releasing system (e.g. AFFF) shall be monitored both for the presence of an alarm condition and for a trouble condition. Provide each monitored condition with a separate address.

2.5 MASS NOTIFICATION SYSTEM FUNCTIONS

2.5.1 Notification Appliance Network

The audible notification appliance network consists of speakers located to provide intelligible instructions at areas as indicated. The Mass Notification System announcements shall take priority over all other audible announcements of the system including the output of the fire alarm system in a normal or alarm state. When a mass notification announcement is activated during a fire alarm, all fire alarm system functions shall continue in an alarm state except for the output signals of the fire alarm audible and visual notification appliances.

2.5.2 Strobes

Provide strobes to alert hearing-impaired occupants.

2.5.3 Text Displays

LED text displays (textural visible appliances) for hearing impaired occupants. The textual displays shall be programmable and shall display the same content of the voice message being played. The signs shall be able to provide a minimum of100 mm (4 inch) high letters and be located in high traffic areas easily seen by building occupants. The system shall interface with the Programmable sign controller to activate the proper message.

2.5.4 Wide Area MNS

The Wide Area MNS system (if available) in the area of the building shall not be activated by the in-building MNS.

2.5.5 Voice Notification

An autonomous voice notification control unit is used to monitor and control the notification appliance network and provide consoles for local operation. Using a console, personnel in the building can initiate delivery of pre-recorded voice messages, provide live voice messages and instructions, and initiate visual strobe and optional textual message notification appliances. The autonomous voice notification control unit will temporarily override audible fire alarm notification while delivering Mass Notification messages to ensure they are intelligible.

2.5.6 Installation-Wide Control

If an installation-wide control system for mass notification exists on the base, the autonomous control unit shall communicate with the central control unit of the installation-wide system. The autonomous control unit shall receive commands/messages from the central control unit and provide status information.

2.6 OVERVOLTAGE AND SURGE PROTECTION

2.6.1 Signaling Line Circuit Surge Protection

For systems having circuits located outdoors, communications equipment shall be protected against surges induced on any signaling line circuit and shall comply with the applicable requirements of IEEE C62.41.1 and IEEE C62.41.2. Cables and conductors that serve as communications links, shall have surge protection circuits installed at each end that meet the following waveform(s):

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Protection shall be provided at the equipment. Additional triple electrode gas surge protectors, rated for the application, shall be installed on each wire line circuit within 1 m (3 feet) of the building cable entrance. Fuses shall not be used for surge protection.

2.6.2 Sensor Wiring Surge Protection

Digital and analog inputs and outputs shall be protected against surges induced by sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested with the following waveforms:

a. A 10 by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Fuses shall not be used for surge protection.

2.7 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored shall be configured as a Class "A" initiating device circuits. The system shall be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling such as waterflow switches, valve supervisory switches, fire pump monitoring, independent smoke detection systems, relays for output function actuation, etc. The module shall be UL or FM listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Pull stations with a monitor module in a common backbox are not required to have an LED. Existing fire alarm system initiating device circuits shall be connected to a single module to power and supervise the circuit.

2.8 ADDRESSABLE CONTROL MODULE

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems, and to control door holders or initiate elevator fire service. The module shall be UL or FM listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Class "B" notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control model shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules shall be located in environmental areas that reflect the conditions to which they were listed.

2.9 ISOLATION MODULES

Provide isolation modules to subdivide each signaling line circuit into groups of not more than 20 addressable devices between adjacent isolation modules.

2.10 SMOKE SENSORS

2.10.1 Photoelectric Smoke Sensors

Provide addressable photoelectric smoke sensors as follows:

a. Provide analog/addressable photoelectric smoke sensors utilizing the photoelectric light scattering principle for operation in accordance with UL 268. Smoke sensors shall be listed for use with the fire alarm control panel.

b. Provide self-restoring type sensors that do not require any readjustment after actuation at the FACP to restore them to normal operation. Sensors shall be UL listed as smoke-automatic fire sensors.

c. Components shall be rust and corrosion resistant. Vibration shall have no effect on the sensor's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen shall not inhibit the movement of smoke particles into the chamber.

d. Provide twist lock bases with sounder that produces a minimum of 90 dBA at 3 m (10 feet) for the sensors. The sensors shall maintain contact with their bases without the use of springs. Provide companion mounting base with screw terminals for each conductor. Terminate field wiring on the screw terminals. The sensor shall have a visual indicator to show actuation.

e. The sensor address shall identify the particular unit, its location within the system, and its sensitivity setting. Sensors shall be of the low voltage type rated for use on a 24 VDC system.

f. An operator at the control panel, having a proper access level, shall have the capability to manually access the following information for each initiating device.

    (1) Primary status

    (2) Device type

    (3) Present average value

    (4) Present sensitivity selected

    (5) Sensor range (normal, dirty, etc.)

2.10.2 Projected Beam Smoke Detectors

Detectors shall be designed for detection of abnormal smoke densities. Detectors shall consist of combined transmitter and receiver unit or separate transmitter and receiver units as indicated. The transmitter unit shall emit an infrared beam to the receiver unit the use of a supplied reflector is required for the combined unit. When the signal at the receiver falls below a preset sensitivity, the detector shall initiate an alarm. The receiver shall contain an LED that is powered upon an alarm condition. Long-term changes to the received signal caused by environmental variations shall be automatically compensated. Detectors shall incorporate features to assure that they are operational; a trouble signal shall be initiated if the beam is obstructed, the limits of the compensation circuit are reached, or the housing cover is removed. Detectors shall have multiple sensitivity settings in order to meet UL listings for the different distances covered by the beam. In the event of beam interference for more than three seconds a trouble alarm shall be transmitted.

2.10.3 Duct Smoke Sensors

Duct-mounted photoelectric smoke detectors shall be furnished and installed where indicated and in accordance with NFPA 90A. Units shall consist of a smoke detector as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. (It is not permitted to cut the duct insulation to install the duct detector directly on the duct). Detectors shall have a manual reset. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s (500 and 4000 fpm). Detectors shall be powered from the fire alarm panel.

a. Sampling tubes shall run the full width of the duct. The duct detector package shall conform to the requirements of NFPA 90A, UL 268 A, and shall be UL listed for use in air-handling systems. The control functions, operation, reset, and bypass shall be controlled from the fire alarm control panel.

b. Lights to indicate the operation and alarm condition; and the test and reset buttons shall be visible and accessible with the unit installed and the cover in place. Remote indicators shall be provided where required by NFPA 72 and these shall be provided with test and reset switches.

c. Remote lamps and switches as well as the affected fan units shall be properly identified in etched plastic placards. Detectors shall provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 23 to LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Auxiliary contacts provide for this function shall be located within 1 m (3 feet) of the controlled circuit or appliance. The detectors shall be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.10.4 Air Sampling Smoke Detectors

Air sampling detectors are early warning devices use to detect what may be the beginning of a fire. The detector uses a series of perforated pipes in the protected area to continuously draw smoke into the sampling chamber. Once in the sampling chamber the air is sampled by mass scattering of light to determine if there is possibly a fire in the protected area. These units shall be programmable in multiple levels to indicate detection of particles that are not normally present, to indicate the presence of particle that could be produced by a fire and to indicate the presence of particles of the proper size and quantity to indicate that a fire conditions exists.

2.10.5 Smoke Sensor Testing

Smoke sensors shall be tested in accordance with NFPA 72 and manufacturer's recommended calibrated test method. Submit smoke sensor testing procedures for approval. In addition to the NFPA 72 requirements, smoke detector sensitivity shall be tested during the preliminary tests.

2.11 HEAT DETECTORS

2.11.1 Heat Detectors

Heat detectors shall be designed for detection of fire by fixed temperature, combination fixed temperature and rate-of-rise principle, or rate-compensating principle as indicated on contract drawings. The alarm condition shall be determined by comparing sensor valve with the stored values. Heat detector spacing shall be rated in accordance with UL 521. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70 and as indicated, shall be types approved for such locations.

2.11.1.1 Combination Fixed-Temperature and Rate-of-Rise Detectors

Detectors shall be designed for surface or semi-flush outlet box mounting and supported independently of wiring connections. Contacts shall be self-resetting after response to rate-of-rise principle. Under fixed temperature actuation, the detector shall have a permanent external indication that is readily visible. Detector units located in boiler rooms, showers, or other areas subject to abnormal temperature changes shall operate on fixed temperature principle only. The UL 521 test rating for the fixed temperature portion shall be as shown. The UL 521 test rating for the Rate-of-Rise detectors shall be rated for 15 by 15 m (50 by 50 feet).

2.11.1.2 Rate Compensating Detectors

Detectors shall be surface or flush mounted vertical or horizontal type, with outlet box supported independently of wiring connections. Detectors shall be hermetically sealed and automatically resetting. Rate Compensated detectors shall be rated for 15 by 15 m (50 by 50 feet).

2.11.1.3 Fixed Temperature Detectors

Detectors shall be designed for surface or semi-flush outlet box mounting and supported independently of wiring connections. Detectors shall be designed to detect high heat. The detectors shall have a specific temperature setting as shown. The UL 521 test rating for the fixed temperature detectors shall be rated for 15 by 15 m (50 by 50 feet).

2.11.2 Self-Test Routines

Automatic self-test routines shall be performed on each sensor that will functionally check sensor sensitivity electronics and ensure the accuracy of the value being transmitted. Any sensor that fails this test shall indicate a trouble condition with the sensor location at the control panel.

2.11.3 Operator Access

An operator at the control panel, having the proper access level, shall have the capability to manually access the following information for each heat sensor:

a. Primary status

b. Device type

c. Present average value

d. Sensor range

2.11.4 Operator Control

An operator at the control panel, having the proper access level, shall have the capability to manually control the following information for each heat sensor:

a. Alarm detection sensitivity values

b. Enable or disable the point/device

c. Control sensors relay driver output

2.12 ELECTRIC POWER

2.12.1 Primary Power

Power shall be 120 VAC service for the FMCP from the AC service to the building in accordance with NFPA 72.

2.13 SECONDARY POWER SUPPLY

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.

2.13.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FMCP. Batteries shall contain suspended electrolyte. The battery system shall be maintained in a fully charged condition by means of a solid state battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.13.1.1 Capacity

Battery size shall be the greater of the following two capacities.

a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 24 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.

b. Sufficient capacity to operate the mass notification for 60 minutes after loss of AC power.

2.13.1.2 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements.

   (1) Substantiate the battery calculations for alarm, alert, and supervisory power requirements. Include ampere-hour requirements for each system component and each panel component, and compliance with UL 864.

   (2) Provide complete battery calculations for the alarm, alert, and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.

   (3) A voltage drop calculation to indicate that sufficient voltage is available for proper operation of the system and all components, at the minimum rated voltage of the system operating on batteries.

b. For battery calculations use the following assumptions: Assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Calculate the nominal battery voltage after operation on batteries for the specified time period. Using this voltage perform a voltage drop calculation for circuit containing device and/or appliances remote from the power sources.

2.13.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger shall be capable of providing 120 percent of the connected system load and shall maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger shall recharge the batteries back to 95 percent of full charge within 48 hours after a single discharge cycle as described in paragraph CAPACITY above. Provide pilot light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided.

2.14 FIRE ALARM CONTROL UNIT AND MASS NOTIFICATION CONTROL UNIT (FMCP)

Provide a complete control panel fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care and maintenance of the systems shall be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control panel, the unit cabinets shall match exactly. If more than a single unit is required, and is located in the lobby/entrance, notify the Contracting Offices Designated Representative (COR), prior to installing the equipment.

a. Each control unit shall provide power, supervision, control, and logic for the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit shall be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each panel with supervisory functions for power failure, internal component placement, and operation.

b. Visual indication of alarm, supervisory, or trouble initiation on the fire alarm control panel shall be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit shall have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.

c. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight pre-recorded messages. Provide the ability to automatically repeat pre-recorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, and initiate/synchronize strobes. Provide a complete set of self-diagnostics for controller and appliance network. Provide local diagnostic information display and local diagnostic information and system event log file.

2.14.1 Cabinet

Install control panel components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of panels as well as field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall say "Fire Alarm and Mass Notification Control Panel" and shall not be less than 25 mm (1 inch) high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet shall be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.

2.14.2 Control Modules

Provide power and control modules to perform all functions of the FACP. Provide audible signals to indicate any alarm, supervisory, or trouble condition. The alarm signals shall be different from the trouble signal. Connect circuit conductors entering or leaving the panel to screw-type terminals with each terminal marked for identification. Locate diodes and resistors, if any, on screw terminals in the FACP. Circuits operating at 24 VDC shall not operate at less than the UL listed voltage at the sensor or appliance connected. Circuits operating at any other voltage shall not have a voltage drop exceeding 10 percent of nominal voltage

2.14.3 Silencing Switches

2.14.3.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCP that shall silence the audible and visual. This switch shall be overridden upon activation of a subsequent alarm.

2.14.3.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch that shall silence the audible trouble and supervisory signal, but not extinguish the visual indicator. This switch shall be overridden upon activation of a subsequent alarm, supervision, or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated.

2.14.4 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Circuits shall be manually reset by switch from the FACP after the initiating device or devices have been restored to normal.

2.14.5 Audible Notification System

The Audible Notification System shall comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements ISO 7240-16, IEC 60268-16, except as specified herein. The system shall be a one-way multi-channel voice notification system incorporating user selectability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of prerecorded messages. Audible appliances shall produce a 3 tone temporal code for three cycles followed by a voice message that is repeated until the control panel is reset or silenced. Automatic messages shall be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message shall override the automatic audible output through use of a microphone input at the control panel or the LOC.

a. When using the microphone, live messages shall be broadcast throughout a selected floor or floors or all call The system shall be capable of operating all speakers at the same time. The Audible Notification System shall support Public Address (PA) paging for the facility. The microprocessor shall actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative shall automatically cause the code 3 temporal tone to take over all functions assigned to the failed unit in the event an alarm is activated.

b. The Mass Notification functions shall override the manual or automatic fire alarm notification or Public Address (PA) functions. Other fire alarm functions including transmission of a signal(s) to the fire department shall remain operational. The system shall have the capability of utilizing LOC with redundant controls of the notification system control panel. Notification Appliance Circuits (NAC) shall be provided for the activation of strobe appliances. The activation of the NAC Circuits shall follow the operation of the speaker NAC circuits. Audio output shall be selectable for line level. Amplifier outputs shall be not greater than 100 watts RMS output. The strobe NAC Circuits shall provide at least 2 amps of 24 VDC power to operate strobes and have the ability to synchronize all strobes. A hand held microphone shall be provided and, upon activation, shall take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC Circuits activation.

2.14.5.1 Outputs and Operational Modules

All outputs and operational modules shall be fully supervised with on-board diagnostics and trouble reporting circuits. Provide form "C" contacts for system alarm and trouble conditions. Provide circuits for operation of auxiliary appliance during trouble conditions. During a Mass

Notification event the panel shall not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.14.5.2 Mass Notification

a. Mass Notification functions shall take precedence over all other function performed by the Audible Notification System. Messages shall utilize a female voice and shall be similar to the following:

(1) 1000 Hz tones (as required in 18.4.2.1 of NFPA 72)

(2) "May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit or exit stairway. Do not use the elevators." (Provide a 2 second pause.) "May I have your attention please, (repeat the message)."

(3) "May I have your attention please. May I have your attention please. A weather alert has been issued for this area, further information will be broadcast as it becomes available." (Provide a 2 second pause.) (repeat the message)

(4) "May I have your attention please. May I have your attention please. A force protection antiterrorism threat has been issued for this area. Effective immediately, we're operating secure and lockdown procedures. All personnel should remain calm and stay where you are. Please wait for further instructions." (Provide a 2 second pause.) (repeat the message)

(5) "May I have your attention please. May I have your attention please. The emergency has now ended. Please resume normal operations. Thank you for your cooperation." (Provide a 2 second pause.) (repeat the message)

(6) "May I have your attention please. May I have your attention please. This is only a test. This is a test of the installation early warning system." (Provide a 2 second pause.) (repeat the message)

b. Include ALL installation specific messages in this section.

c. The LOC shall incorporate a Push-To-Talk (PTT) microphone, redundant controls and system status indicators of/for the system. The unit shall incorporate microphone override of any tone generation or prerecorded messages. The unit shall be fully supervised from the control panel. The housing shall contain a latch (not lock).

d. Auxiliary Input Module shall be designed to be an outboard expansion module to either expand the number of optional LOC, or allow a telephone interface.

e. Local Operating Console (LOC) shall incorporate a Push-To-Talk (PTT) microphone, and controls to allow Public Address paging in the facility. The Public Address paging function shall not override any alarm or notification functions and shall be disabled by such signals. The microphone shall be desktop or handheld style. All wiring to the LOC shall be supervised in accordance with UFC 4-021-01. Systems that require field modification or are not supervised for multiple LOC's shall not be approved.

f. When an installation has more than one LOC, each LOC shall be programmed to allow only one LOC to be available for page or messaging at a time. Once one LOC becomes active, all other LOC's will have an indication that the system is busy (Amber Busy Light)and cannot be used at that time. This is to avoid two messages being given at the same time. Also, it must be possible to override or lockout the LOC's from the Master Command Panel (in accordance with NFPA 72.)

2.14.6 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices shall not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.14.7 Field Programmability

Provide control units and control panels that are fully field programmable for control, initiation, notification, supervisory, and trouble functions of both input and output. The system program configuration shall be menu driven. System changes shall be password protected and shall be accomplished using personal computer based equipment. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

2.14.8 Input/Output Modifications

The FMCP shall contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features shall consist of a panel mounted keypad and a keyboard. Any bypass or modification to the system shall indicate a trouble condition on the FMCP.

2.14.9 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory or trouble condition on the system still exists.

2.14.10 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the instructions on the interior of the FACP. The card shall show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions shall be approved by the Contracting Officer before being posted.

2.14.11 Walk Test

The FACP shall have a walk test feature. When using this feature, operation of initiating devices shall result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated on the system printer, but no other outputs occur.

2.14.12 History Logging

In addition to the required printer output, the control panel shall have the ability to store a minimum of 400 events in a log. These events shall be stored in a battery-protected memory and shall remain in the memory until the memory is downloaded or cleared manually. Resetting of the control panel shall not clear the memory.

2.14.13 Remote LCD Text Display

An LCD text display shall be provided at locations as shown on the drawings. The size shall not exceed 400 mm length by 150 mm height by 75 mm deep (16 inches length by 3 inches deep) with a height necessary to meet the requirements of Chapter 24 of NFPA 72). The text display shall as a minimum meet the following requirements:

a. Two lines of information for high priority messaging.

b. Minimum of 20 characters per line (40 total) displayed.

c. Text shall be no less than height requirements in Table 24.4.2.20.14.5 of NFPA 72 and color/contrast requirements of 24.4.2.20 of NFPA 72.

d. 32K character memory.

e. Display shall be wall or ceiling mounted.

f. Mounting brackets for a convenient wall/cubicle mount.

g. During non-emergency periods, display date and time.

h. All programming shall be accomplished from the Mass Notification network. No user programming shall be required.

An LCD text display shall be provided at locations as shown on the drawings. The LCD text display shall spell out the words "EVACUATE" and "ANNOUNCEMENT" and the remainder of the emergency instructions. The design of LCD text display shall be such that it cannot be read when not illuminated.

2.15 REMOTE FIRE ALARM/MASS NOTIFICATION CONTROL UNITS

Provide complete remote control units fully enclosed in a lockable steel enclosure as specified herein. Operations required for testing or for normal care and maintenance of the control units shall be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control panel, the unit enclosures shall match exactly. Each control unit shall provide power, supervision, control, and logic for its portion of the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit shall be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each unit with supervisory functions for power failure, internal component placement, and operation.

2.15.1 Cabinet

Install remote control unit components in cabinets large enough to accommodate components and also to allow ample gutter space for interconnection of units as well as field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall be labeled "Remote Fire Alarm/Mass Notification Control Unit" and shall not be less than one inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet shall be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock (keyed the same as the FMCP), and surface mounting provisions.

2.15.2 Control Modules

Provide power and control modules to perform all functions of the remote control unit. Provide audible signals to indicate any alarm or trouble condition. The alarm signals shall be different from the trouble signal. Connect circuit conductors entering or leaving the panel to screw-type terminals with each terminal marked for identification. Locate diodes and relays, if any, on screw terminals in the remote control unit. Circuits shall not have a voltage drop exceeding 10 percent of nominal voltage. Circuits shall be arranged so that there is 25 percent spare capacity for any circuit.

2.15.3 Silencing Switches

Provide an alarm silencing switch at the remote control unit that shall silence the audible signal and extinguish the visual alarms. This switch shall be overridden upon activation of a subsequent alarm. Provide trouble and supervisory silencing switch that shall silence the audible trouble and supervisory signal, but not extinguish the visual indicator. This switch shall be overridden upon activation of a subsequent trouble or supervisory signal. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated.

2.15.4 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Circuits shall be manually resettable by switch from the remote control unit after the initiating device or devices have been restored to normal.

2.15.5 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices shall not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.15.6 Field Programmability

Provide control units that are fully field programmable for control, initiating, supervisory, and trouble functions of both input and output. The system program configuration shall be menu driven. System changes shall be password protected and shall be accomplished using personal computer based equipment. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

2.15.7 Input/Output Modifications

Each remote control unit shall contain features that allow the elimination of input devices from the system or the modification of system outputs.

Any such modifications shall indicate a trouble condition on the remote control unit, the FACP, and a printed output of the trouble condition.

2.15.8 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory, or trouble condition on the system still exists.

2.15.9 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the remote fire alarm control unit. The card shall show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions shall be approved by the Contracting Officer before being posted.

2.15.10 Walk Test

Each remote control unit shall have a walk test feature. When using this feature, operation of initiating devices shall result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated on the system printer, but no other outputs occur.

2.15.11 History Logging

In addition to the required printer output, the control panel shall have the ability to store a minimum of 1000 events in a log. These events shall be stored in a battery-protected memory and shall remain in the memory until the memory is downloaded or cleared manually. Resetting of the control panel shall not clear the memory.

2.16 AMPLIFIERS, PREAMPLIFIERS, TONE GENERATORS

Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 shall be housed in a remote FMCP, terminal cabinet, or in the FMCP. Submit data to indicate that the amplifiers have sufficient capacity to simultaneously drive all notification speakers at the maximum rating plus 50 percent spare capacity. Annotate data for each circuit on the drawings.

2.16.1 Operation

The system shall automatically operate and control all building speakers except those installed in the stairs and within elevator cabs. The speakers in the stairs and elevator cabs shall operate only when the microphone is used to deliver live messages.

2.16.2 Construction

Amplifiers shall utilize computer grade solid state components and shall be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.

2.16.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and panel mounted microphone Public Address Paging Function (where allowed). Microphone inputs shall be of the low impedance, balanced line type. Both microphone and tone generator input shall be operational on any amplifier.

2.16.4 Tone Generator

The tone generator shall be of the modular, plug-in type with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces. The tone generator shall produce a code 3 temporal tone and shall be constantly repeated until interrupted by the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator shall be single channel with an automatic backup generator per channel such that failure of the primary tone generator causes the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay.

2.16.5 Protection Circuits

Each amplifier shall be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component shall cause automatic transfer to a designated backup amplifier, illumination of a visual "amplifier trouble" indicator on the control panel, appropriate logging of the condition on the system printer, and other actions for trouble conditions as specified.

2.17 ANNUNCIATOR

2.17.1 Annunciator Panel

Provide an annunciator that includes an LCD display. The display shall indicate the device in trouble/alarm or any supervisory device. Display the device name, address, and actual building location.

A building floor plan shall be provided mounted (behind plexiglass or similar protective material) at the annunciator location. The floor plan shall indicate all rooms by name and number including the locations of stairs and elevators. The floor plan shall show all devices and their programmed address to facilitate their physical location from the LCD display information.

2.17.2 Programming

Where programming for the operation of the annunciator is accomplished by a separate software program than the software for the FMCP, the software program shall not require reprogramming after loss of power. The software shall be reprogrammable in the field.

2.18 MANUAL STATIONS

Provide metal or plastic, semi-flush mounted, single action, addressable manual stations that are not subject to operation by jarring or vibration. Stations shall be equipped with screw terminals for each conductor. Stations that require the replacement of any portion of the device after activation are not permitted. Stations shall be finished in fire-engine red with molded raised lettering operating instructions of contrasting color. The use of a key or wrench shall be required to reset the station. Manual stations shall be mounted at 1117 mm (44 inches). Stations shall have a separate screw terminal for each conductor.

2.19 NOTIFICATION APPLIANCES

2.19.1 Fire Alarm/Mass Notification Speakers

Audible appliances shall conform to the applicable requirements of UL 464. Appliances shall be connected into notification appliance circuits. Surface mounted audible appliances shall be painted red. Recessed audible appliances shall be installed with a grill that is painted red.

a. Speakers shall conform to the applicable requirements of UL 1480. Speakers shall have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Tap settings shall include taps of 1/8, 1/4, 1/2, 1, and 2 watts. Speakers shall incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 150 Hz to 10,000 Hz, and shall have a sealed back construction. Speakers shall be capable of installation on standard 100 mm (4 inch) square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single wall mounted unit. All inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCP.

b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 1.519 mm (16 gauge) (16 gauge) or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.

c. Speakers shall utilize screw terminals for termination of all field wiring.

2.19.2 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and conform to the Architectural Barriers Act (ABA). Colored lens, such as amber, shall comply with UL 1638. The manufacturer shall have the color lens tested to the full UL 1971 polar plotting criteria, voltage drop, and temperature rise as stated in 1971. Fire Alarm Notification Appliances shall have clear high intensity optic lens, xenon flash tubes, and be marked "Fire" in red letters unless otherwise indicated in contract drawings. Fire Alarm/Mass Notification Appliances shall have amber high intensity optic lens, xenon flash tubes, and output white light and be marked "ALERT" in red letters. The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate shall be 1 flash per second and a minimum of 75 candela (actual output after derating for tinted lens) based on the UL 1971 test. Strobe shall be surface or semi-flush mounted. Where more than two appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices shall use screw terminals for all field wiring.

2.19.3 Chimes

Chimes shall be electrically operated, supervised, electronic type, with an adjustable frequency of 800 to 1200 Hertz. Chimes shall have a minimum sound rating of 80 dBA at 3 m (10 feet). Chimes shall ring the bell codes, as indicated.

2.20 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures shall be provided to permit Fire Alarm or Mass Notification components to be used in areas that exceed the environmental limits of the listing. The enclosure shall be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the UL category that the component is currently listed. Guards required to deter mechanical damage shall be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

2.21 INTERFACE TO THE BASE WIDE MASS NOTIFICATION NETWORK

2.21.1 Radio

The radio transceiver shall be bi-direction and meet all the requirements of paragraph, RADIO TRANSMITTER AND INTERFACE PANELS as specified in this Specification Section. The transceiver utilized in the Mass Notification System shall be capable of the following:

a. Communication with the Central Control/Monitoring System to provide supervision of communication link and status changes are reported by automatic and manual poll/reply/acknowledge routines.

b. All monitored points/status changes are transmitted immediately and at programmed intervals until acknowledged by the Central Control/Monitoring System.

c. Each transceiver shall transmits a unique identity code as part of all messages; the code is set by the user at the transceiver.

2.21.1.1 Radio Frequency Communications

Use of radio frequency-type communications systems shall comply with National Telecommunications and Information Administration (NTIA) requirements.

2.21.2 Secure Radio System

2.21.2.1 Communications Network

The communications network provides two-way signals between central control units and autonomous control units (in individual building systems), and should include redundant (primary and backup) communication links. The system shall incorporate technology to prevent easy interruption of the radio traffic for MNS Alerting.

2.21.2.2 Radio Frequency Communications

Use of radio frequency-type communications systems shall comply with National Telecommunications and Information Administration (NTIA) requirements. The systems shall be designed to minimize the potential for interference, jamming, eavesdropping, and spoofing.

2.21.2.3 Licensed Radio Frequency Systems

An approved DD Form 1494 for the system is required prior to operation.

2.22 AUTOMATIC FIRE TRANSMITTERS

2.22.1 Radio Transmitter and Interface Panels

Transmitters shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters shall be provided in accordance with applicable portions of NFPA 72, Federal Communications Commission (FCC) 47 CFR 90 and Federal Communications Commission (FCC) 47 CFR 15. Transmitter electronics module shall be contained within the physical housing as an integral, removable assembly. The transceiver shall be fully compatible with proprietary supervising station receiving equipment. At the contractors option, and if UL or FM listed, the transmitter may be housed in the same panel as the fire alarm control panel. The transmitter shall be Narrowband radio, with FCC certification for narrowband operation.

a. Operation: Each transmitter shall operate from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

b. Battery Power: Transmitter standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

c. Transmitter housing shall be NEMA Type 1. The housing shall contain a lock that is keyed identical to radio alarm transmitter housings on the base. Radio alarm transmitter housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

d. Antenna shall be omnidirectional, coaxial, half-wave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall be corrosion resistant and designed to withstand wind velocities of 161 km/hour (100 mph). Do not mount antennas to any portion of the building roofing system. Protect the antenna from physical damage.

2.22.2 Signals to Be Transmitted to the Base Receiving Station

The following signals shall be sent to the base receiving station:

a. Sprinkler water flow

b. Manual pull stations

c. Smoke detectors

d. Duct smoke detectors

e. Sleeping room smoke detectors

f. Heat detectors

g. Fire Extinguishing System

h. Sprinkler valve supervision

i. Fire pump running

j. Fire pump supervision

k. Water supply level and temperature

l. Combustion Engine Drive Fire Pump Running

    (1) Selector Switch in position than automatic

    (2) Engine Over-speed

    (3) Low Fuel

    (4) Low Battery

    (5) Engine Trouble (Low Oil, Over temp, etc)

2.23 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein. NFPA 70 accepted fire alarm cables that do not require the use of raceways except as modified herein are permitted.

2.23.1 Alarm Wiring

The SLC wiring shall be solid copper cable in accordance with the manufacturer's requirements. Copper signaling line circuits and initiating device circuit field wiring shall be No. 16 AWG size twisted and shielded solid conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, shall be solid copper No. 14 AWG size conductors at a minimum. Speaker circuits shall be copper No. 16 AWG size twisted and shielded conductors at a minimum. Wire size shall be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC shall not operate at less than the UL listed voltages for the sensors and/or appliances. Power wiring, operating at 120 VAC minimum, shall be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Non-power-limited cables shall comply with NFPA 70.

PART 3 EXECUTION

3.1 INSTALLATION OF FIRE ALARM INITIATING DEVICES AND NOTIFICATION APPLIANCES

3.1.1 FMCP

Locate the FMCP where indicated on the drawings. Recess, Semi-recess, or Surface mount the enclosure with the top of the cabinet 2 m (6 feet) above the finished floor or center the cabinet at 1.5 m (5 feet), whichever is lower. Conductor terminations shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the FMCP.

3.1.2 Manual Stations:

Locate manual stations as required by NFPA 72 and as shown on the drawings. Mount stations so that their operating handles are 1220 mm (4 feet) above the finished floor. Mount stations so they are located no farther than 1.5 m (5 feet) from the exit door they serve, measured horizontally.

3.1.3 Notification Appliance Devices

Locate notification appliance devices where indicated. Mount assemblies on walls as required by NFPA 72 and to meet the intelligibility requirements. Ceiling mounted speakers shall conform to NFPA 72.

3.1.4 Smoke and Heat Sensors

Locate sensors as indicated on a 100 mm (4 inch) mounting box. Locate smoke and heat sensors on the ceiling. Install heat sensors not less than 100 mm (4 inches) from a side wall to the near edge. Heat sensors located on the wall shall have the top of the sensor at least 100 mm(4 inches) below the ceiling, but not more than 300 mm (12 inches) below the ceiling. Smoke sensors are permitted to be on the wall no lower than 300 mm (12 inches) from the ceiling with no minimum distance from the ceiling. In raised floor spaces, install the smoke sensors to protect 21 square meters (225 square feet) per sensor. Install smoke sensors no closer than 1.5 m (5 feet) from air handling supply outlets.

3.1.5 Annunciator

Locate the annunciator as shown on the drawings. Surface mount the panel, with the top of the panel 2 m (6 feet) above the finished floor or center the panel at 1.5 m (5 feet), whichever is lower.

3.1.6 Water Flow Detectors and Tamper Switches

Connect to water flow detectors and tamper switches.

3.1.7 Firefighter Telephones

Locate wall mounted in each stair at each floor landing, in each elevator lobby, and in each elevator cab 1220 mm (4 feet) above the finished floor.

3.1.8 Local Operating Console (LOC)

Locate the LOC as required by NFPA 72 and as indicated. Mount the console so that the top message button is no higher than 1117 mm (44 inches) above the floor.

3.2 SYSTEM FIELD WIRING

3.2.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box shall be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Wiring shall conform to NFPA 70.

Indicate the following in the wiring diagrams.

a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams shall show connections from field devices to the FACP and remote fire alarm control units, initiating circuits, switches, relays and terminals.

b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.2.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size shall be appropriate for the size of the wiring to be connected. Conductor terminations shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the terminal cabinet. Minimum size is 200 mm by 200 mm (8 inches by 8 inches). Only screw-type terminals are permitted.

3.2.3 Alarm Wiring

Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Provide all wiring in electrical metallic. Conceal conduit in finished areas of new construction and wherever practicable in existing construction. The use of flexible conduit not exceeding a 2 m (6 foot) length shall be permitted in initiating device or notification appliance circuits. Run rigid metal conduit concealed unless specifically indicated otherwise.

Use of cables that do not require a raceway as stated hereinbefore are permitted; install them in accordance with NFPA 70. Protect any exposed (as defined in NFPA 70) cables against physical damage by the use of magnetic raceways which shall also be red colored. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at a single point that is in or adjacent to the FMCP. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. T-tapping using screw terminal blocks is allowed for Class "B" signaling line circuits. Color coding is required for circuits and shall be maintained throughout the circuit. Conductors used for the same functions shall be similarly color coded. Wiring shall conform to NFPA 70.

3.2.4 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCP, and remote FMCP and the LOC shall be provided at each conductor connection. Each conductor or cable shall have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCP, and remote FMCP shall contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing shall be neat, using 12 point lettering minimum size, and mounted within each cabinet, panel, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.3 DISCONNECTION AND REMOVAL OF EXISTING SYSTEM

Maintain existing fire alarm equipment fully operational until the new equipment has been tested and accepted by the Contracting Officer. As new equipment is installed, label it "NOT IN SERVICE" until the new equipment is accepted. Once the new system is completed, tested, and accepted by the Government, it shall be placed in service and connected to the station fire alarm system. Remove tags from new equipment and tag the existing equipment "NOT IN SERVICE" until removed from the building.

a. After acceptance of the new system by the Contracting Officer, remove existing equipment not connected to the new system, remove unused exposed conduit, and restore damaged surfaces. Remove the material from the site and dispose.

b. Disconnect and remove the existing fire alarm and smoke detection systems where indicated and elsewhere in the specification.

c. Control panels and fire alarm devices and appliances disconnected and removed shall be turned over to the Contracting Officer.

d. Properly dispose of fire alarm outlet and junction boxes, wiring, conduit, supports, and other such items.

3.4 CONNECTION OF NEW SYSTEM

The following new system connections shall be made during the last phase of construction, at the beginning of the preliminary tests. New system connections shall include:

a. Connection of new control modules to existing magnetically held smoke door (hold-open) devices.

b. Connection of new elevator recall smoke sensors to existing wiring and conduit.

c. Connection of new system transmitter to existing base fire reporting system.

Once these connections are made, system shall be left energized and new audio/visual devices deactivated. Report immediately to the Contracting Officer, coordination and field problems resulting from the connection of the above components.

3.5 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire rated walls, partitions with fire rated doors, corridor walls, and vertical service shafts in accordance with Section 07 84 00 FIRESTOPPING.

3.6 PAINTING

Paint exposed electrical, fire alarm conduit, and surface metal raceway to match adjacent finishes in exposed areas. Paint junction boxes red in unfinished areas and conduits and surface metal raceways shall be painted with a 25 mm (1-inch) wide red band every 3 m (10 feet) in unfinished areas.. Painting shall comply with Section 09 90 00 PAINTS AND COATINGS.

3.7 FIELD QUALITY CONTROL

3.7.1 Testing Procedures

Submit detailed test procedures, prepared and signed by a Registered Professional Engineer or a NICET Level 3 or 4 Fire Alarm Technician, and signed by representative of the installing company, for the fire detection and alarm system 30 days prior to performing system tests. Detailed test procedures shall list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, Guard's Tour equipment, and transient (surge) suppressors. Test procedures shall include sequence of testing, time estimate for each test, and sample test data forms. The test data forms shall be in a check-off format (pass/fail with space to add applicable test data; similar to the forma in NFPA 72) and shall be used for the preliminary testing and the acceptance testing. The test data forms shall record the test results and shall:

a. Identify the NFPA Class of all Initiating Device Circuits (IDC), Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).

b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how this test shall be performed.

c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.

d. Identify all test equipment and personnel required to perform each test (including equipment necessary for testing smoke detectors using real smoke).

e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.7.2 Tests Stages

3.7.2.1 Preliminary Testing

Conduct preliminary tests to ensure that devices and circuits are functioning properly. Tests shall meet the requirements of paragraph entitled "Minimum System Tests." After preliminary testing is complete, provide a letter certifying that the installation is complete and fully operable. The letter shall state that each initiating and indicating device was tested in place and functioned properly. The letter shall also state that panel functions were tested and operated properly. The letter shall include the names and titles of the witnesses to the preliminary tests. The Contractor and an authorized representative from each supplier of equipment shall be in attendance at the preliminary testing to make necessary adjustments.

3.7.2.2 Request for Formal Inspection and Tests

When tests have been completed and corrections made, submit a signed, dated certificate with a request for formal inspection and tests to the Contracting Offices Designated Representative (COR).

3.7.2.3 Final Testing

Notify the Contracting Officer in writing when the system is ready for final acceptance testing. Submit request for test at least 10 calendar days prior to the test date. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. Furnish instruments and personnel required for the tests. A final acceptance test will not be scheduled until the following are provided at the job site:

a. The systems manufacturer's technical representative
b. Marked-up red line drawings of the system as actually installed

c. Megger test results

d. Loop resistance test results

e. Complete program printout including input/output addresses

The final tests will be witnessed by the Contracting Offices Designated Representative (COR). At this time, any and all required tests shall be repeated at their discretion.

3.7.2.4 System Acceptance

Following acceptance of the system, as-built drawings and O&M manuals shall be delivered to the Contracting Officer for review and acceptance. Submit six sets of detailed as-built drawings. The drawings shall show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings shall be submitted within two weeks after the final acceptance test of the system. At least one set of as-built (marked-up) drawings shall be provided at the time of, or prior to the final acceptance test.

a. Submit as-built drawings, no later than 14 days after completion of Final Tests. Drawings shall be updated to reflect as-built conditions after all related work is completed and be prepared as discussed in

Section 01 33 00 SUBMITTAL PROCEDURES. Furnish one set of CD or DVD discs containing software back-up and CAD based drawings in latest version of MicroStation and DXF format of as-built drawings and schematics.

b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.

c. Include a riser diagram and drawings showing the as-built location of devices and equipment.

In existing buildings, the transfer of devices from the existing system to the new system and the permission to begin demolition of the old fire alarm system will not be permitted until the as-built drawings and O&M manuals are received.

3.7.3 Minimum System Tests

Test the system in accordance with the procedures outlined in NFPA 72, ISO 7240-16, IEC 60268-16. The required tests are as follows:

a. Megger Tests: After wiring has been installed, and prior to making any connections to panels or devices, wiring shall be megger tested for insulation resistance, grounds, and/or shorts. Conductors with 300 volt rated insulation shall be tested at a minimum of 250 VDC. Conductors with 600 volt rated insulation shall be tested at a minimum of 500 VDC. The tests shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.

b. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.

c. Verify the absence of unwanted voltages between circuit conductors and ground. The tests shall be accomplished at the preliminary test with results available at the final system test.

d. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.

e. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke sensors shall be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors shall comply with the requirements of NFPA 72 except that, for item 12(e) (Supervision) in Table 14.4.2.2, disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision shall be tested at each device.

f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.

g. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.

h. Determine that the system is operable under trouble conditions as specified.

i. Visually inspect wiring.

j. Test the battery charger and batteries.

k. Verify that software control and data files have been entered or programmed into the FACP. Hard copy records of the software shall be provided to the Contracting Officer.

l. Verify that red-line drawings are accurate.

m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.

n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

o. Disconnect the verification feature for smoke sensors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke sensors shall be conducted using real smoke or the use of canned smoke which is permitted.

p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.

3.7.3.1 Intelligibility Tests

Intelligibility testing of the System shall be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, IEC 60268-16, and ASA S3.2. Following are the specific requirements for intelligibility tests:

a. Intelligibility Requirements: Verify intelligibility by measurement after installation.

b. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is .7 .

c. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the DOD installation, and if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 10 m 33 feet to find a location with at least the minimum required CIS value within the same area.

d. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 15 m 50 feet to a location with at least the minimum required CIS value within the same area.

e. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).

f. The distance the occupant must walk to the location meeting the minimum required CIS value shall be measured on the floor or other walking surface as follows:

(1) Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.

(2) Curving around any corners or obstructions, with a 300 mm 12 inches clearance there from.

(3) Terminating directly below the location where the minimum required CIS value has been obtained.

Use commercially available test instrumentation to measure intelligibility as specified by ISO 7240-19 and ISO 7240-16 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.8 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.8.1 Instructor

Include in the project the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the inspection, testing, and maintenance of the system provided. The instructor shall train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm and fire detection system. Each instructor shall be thoroughly familiar with all parts of this installation. The instructor shall be trained in operating theory as well as in practical O&M work. Submit the instructor's information and qualifications including the training history.

3.8.2 Required Instruction Time

Provide 8 hours of instruction after final acceptance of the system. The instruction shall be given during regular working hours on such dates and times as are selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training shall allow for rescheduling for unforeseen maintenance and/or fire department responses.

3.9 Technical Data and Computer Software

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training shall familiarize designated government personnel with proper operation of the installed system. The maintenance training course shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

-- End of Section --

SECTION 31 00 00

EARTHWORK
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2010) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C2	(2003) Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes
AWPA P5	(2010) Standard for Waterborne Preservatives

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M	(2004; R 2010) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A252	(2010) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C33/C33M	(2013) Standard Specification for Concrete

	Aggregates
ASTM D1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1883	(2007; E 2009; E 2009) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2937	(2010) Density of Soil in Place by the Drive-Cylinder Method
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2302	(2002) Test Method for Particle Size Distribution of Soils
KS F 2303	(2000) Test Method for Liquid Limit and Plastic Limit of Soils
KS F 2309	(2009) Standard test method for amount of material in passing standard sieve 0.075mm in soils
KS F 2311	(2001) Test Method for Soil Density by the Sand Replacement Method
KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer

KS F 2320	(2000) California Bearing Ratio of Soils
KS F 2322	(2000) Permeability of Saturated Soils
KS F 2324	(2006) Method of Classification of Soils for Engineering Purposes
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method
KS F 2526	(2007) Aggregate for Concrete

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203	(Rev C; Notice 3) Paper, Kraft, Untreated

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, . Satisfactory materials for grading comprise stones less than 200 mm (8 inches), except for fill material for pavements and railroads which comprise stones less than 75 mm (3 inches) in any dimension.

1.2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 or KS F 2324 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318 or KS F 2303; ASTM C136; ASTM D422 or KS F 2302 and ASTM D1140 or KS F 2309.

1.2.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 or KS F 2312 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 or KS F 2312 applies only to soils that have 30 percent or less by weight of their particles retained on the 19.0 mm (3/4 inch) sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 19.0 mm (3/4 inch) sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.2.5 Topsoil

Material suitable for topsoil is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than 25 mm (one inch) diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.2.6 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 75 mm (3 inches) in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.7 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 0.375 cubic meter (1/2 cubic yard) in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.8 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.2.9 Select Granular Material

1.2.9.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW,or SP by ASTM D2487or KS F 2324 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318 or KS F 2303. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318 or KS F 2303, and not more than 35 percent by weight may be finer than 75 micrometers (No. 200) sieve when tested in accordance with ASTM D1140. Provide a minimum coefficient of permeability of 0.01 mm per second (0.002 feet per minute) when tested in accordance with ASTM D2434 or KS F 2322.

1.2.9.2 California Bearing Ratio Values

Bearing Ratio: At 2.5 mm (0.1 inch) penetration, provide a bearing ratio of 100 percent at 95 percent ASTM D1557 or KS F 2312 maximum density as determined in accordance with ASTM D1883 or KS F 2320 for a laboratory soaking period of not less than 4 days. Conform the combined material to the following sieve analysis:

Sieve Size	Percent Passing by Weight
63 mm	100
4.75 mm	40 - 85
2.00 mm	20 - 80
425 micrometers	10 - 60
75 micrometers	5 - 25

Sieve Size	Percent Passing by Weight
2 1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

1.2.10 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 75 mm (3 inches) or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free the initial backfill material of stones larger than 75 mm (3 inches) in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

1.2.11 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 35 when tested in accordance with ASTM D4318 or KS F 2303.

1.2.12 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material are a uniformly graded washed sand with a maximum particle size of 6 mm (1/4 inch) and less than 5 percent passing the 0.075 mm (No. 200) size sieve, and with not more than 3 percent by weight finer than 0.02 mm (No.635)grain size.

1.2.13 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.3 SYSTEM DESCRIPTION

Subsurface soil boring logs, if available, are shown on the drawings . These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.3.1 Classification of Excavation

Finish the specified excavation on a classified basis, in accordance with the following designations and classifications.

1.3.1.1 Common Excavation

Include common excavation with the satisfactory removal and disposal of all materials not classified as rock excavation.

1.3.1.2 Rock Excavation

Submit notification of encountering rock in the project. Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic meter (yard) or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic meter (yard) in volume that may be encountered in the work in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, uncover such material and notify the Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

1.3.2 Blasting

Blasting will not be permitted.

1.3.3 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring; G
Dewatering Work Plan; G
Blasting; G

SD-03 Product Data

Utilization of Excavated Materials; G
Rock Excavation
Opening of any Excavation or Borrow Pit
Shoulder Construction

Structural Backfill

SD-06 Test Reports

Testing
Borrow Site Testing

SD-07 Certificates

Testing

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

Offsite soils brought in for use as backfill shall be tested for Total Petroleum Hydrocarbons (TPH) and Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX). Backfill shall contain less than 100 parts per million (ppm) TPH, less than 1 ppm Benzene, less than 20 ppm Toluene, less than 50 ppm Ethyl Benzene, and less than 15 ppm Xylene. Determine TPH concentrations by using EPA SW-846.3-3 Method 8015. Determine BTEX concentrations by using EPA SW-846.3-3 Method 8021 or 8260

Provide borrow site testing for TPH and BTEX from composite samples of soil collected from the borrow site, with the composite samples being representative of the soil to be acquired for the project. Surface samples shall be obtained by excavating a minimum of 200 mm (8 inches) from the surface. For borrow sites 8093 square meter (2 acres) or less, 1 composite sample shall be collected from the site for analysis. For borrow sites larger than 8093 square meter (2 acres), 1 sample for each additional 8093 square meter (2 acres) increment shall be collected. For borrow excavations deeper than 2 meters (6 feet), the above sampling protocol shall be repeated again with every 2 meter (6 feet) increase in depth.

For each prospective borrow site, the contractor shall submit to the Contracting Officer a Borrow Site Environmental Assessment Report which documents that borrow soil from the site is not contaminated. The Borrow Site Environmental Assessment Report shall include the following: general site description and environmental condition; location information and map; historic and current land use; photographs; any known contaminant spills in the area; any on-site or adjacent facilities which pose risks of contaminating the borrow fill; procedures for soil sample collection and collection locations; and the laboratory testing procedures and resulting analytical data. The report shall have a cover sheet that is signed by the contractor, which attests and certifies the suitability of the fill material. Soil from a particular borrow site shall not be brought onsite until this report has been approved by the Contracting Officer.

2.2 BURIED WARNING AND IDENTIFICATION TAPE

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 75 mm (3 inches) minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes

Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.08 mm (0.003 inch) and a minimum strength of 10.3 MPa (1,500 psi) lengthwise, and 8.6 MPa (1250 psi) crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.10 mm (0.004 inch), and a minimum strength of 10.3 MPa (1500 psi) lengthwise and 8.6 MPa (1250 psi) crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 920 mm (3 feet) deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 2 mm (No. 12 AWG).

2.4 MATERIAL FOR RIP-RAP

Provide bedding material, grout, filter fabric and rock conforming to these requirements for construction indicated.

2.4.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, or poorly graded with a maximum particle size of 50 mm (2 inches). Compose material of tough, durable particles. Allow fines passing the 75 micrometers (No. 200) standard sieve with a plasticity index less than six.

2.4.2 Grout

Provide durable grout composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one part Portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air, as determined by the Contracting Officer. Mix grout in a concrete mixer. Allow a sufficient mixing time to produce a mixture having a consistency permitting gravity flow into the interstices of the rip-rap with limited spading and brooming.

2.4.3 Rock

Provide rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized so that no individual fragment exceeds a weight of 68 kg (150 pounds) and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 0.91 kg (2 pounds) or less each. Provide rock with a minimum specific gravity of 2.50. Do not permit the inclusion of more than trace 1 percent quantities of dirt, sand, clay, and rock fines.

2.5 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Conform to ASTM C33/C33M or KS F 2526 for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140 or KS F 2309, 75 micrometers (No. 200) sieve, or 37.5 mm (1-1/2 inch) and no more than 2 percent by weight passing the 4.75 mm (No. 4) size sieve.

2.6 PIPE CASING

2.6.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Match casing size to the outside diameter and wall thickness as indicated on Drawing . Protective coating is not required on casing pipe.

2.6.2 Wood Supports

Treated Yellow Pine or Douglas Fir, rough, structural grade. Provide wood with nonleaching water-borne pressure preservative (ACA or CCA) and treatment conforming to AWPA P5 and AWPA C2, respectively. Secure wood supports to carrier pipe with stainless steel or zinc-coated steel bands.

2.7 STRUCTURAL BACKFILL

Structural backfill is a well-graded sand and gravel mixture that is further classified as nonfrost susceptible material. Structural backfill consists of sand, gravel, crushed gravel, or crushed rock composed of hard, tough and durable particles, and shall be reasonable well-graded within the limits given below. Structural backfill shall be placed and compacted in maximum 150 mm (6 inches) loose lifts to achieve a uniform compaction of at least 100 percent of laboratory maximum density.

Sieve Designation, mm (inch)	Percent Finer by Weight
40 mm (1-1/2 inches)	100
13 mm (1/2 inch)	48-100
10 mm (3/8 inch)	42-84
4.75 mm (No. 4)	28-58
2.00 mm (No. 10)	15-40
0.425 mm (No. 40)	4-19
0.075 mm (No. 200)	0-4

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 100 mm (4 inches). Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 50 mm (2 inches) in diameter, and other materials that would interfere with planting and maintenance operations. Stockpile in locations indicated any surplus of topsoil from excavations and gradings.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

3.2.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on Drawing . Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 1 meter (4 feet) from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.2.2 Drainage Structures

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed. Where pile foundations are to be used, stop the excavation of each pit at an elevation

300 mm (1 foot) above the base of the footing, as specified, before piles are driven. After the pile driving has been completed, remove loose and displaced material and complete excavation, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry.

3.2.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.4 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 0.9 m (3 feet) of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously, at least .91 m (3 feet) below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly.

3.2.5 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 1.5 meters (5 feet) high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in. Shore vertical trench walls more than 1.5 meters (5 feet) high. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 600 mm (24 inches) plus pipe outside diameter (O.D.) for pipes of less than 600 mm (24 inches) inside diameter, and do not exceed 900 mm (36 inches) plus pipe outside diameter for sizes larger than 600 mm (24 inches) inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.2.5.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 75 mm 3inches or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.2.5.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, remove such material 100 mm (4inches) below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.2.5.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.2.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.5.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Contracting Officer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.2.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Excavation made with power-driven equipment is not permitted within 600 mm (2 feet) of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.2.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact over excavations and changes in grade due to pile driving operations to 95 percent of ASTM D698 maximum density.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from the borrow areas designated by Contracting Officer if indicated on drawings or from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

3.4 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Contracting Officer sufficiently in advance of the opening of any excavation or borrow pit or borrow areas to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate borrow pits and other excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Provide neatly trimmed and drained borrow pits after the excavation is completed. Ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.5 SHORING

3.5.1 General Requirements

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.5.2 Geotechnical Engineer

Hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions.

The Geotechnical Engineer is responsible for updating the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contracting Officer is responsible for arranging meetings with the Geotechnical Engineer at any time throughout the contract duration.

3.6 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Do not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Place and grade stockpiles of satisfactory, unsatisfactory, and wasted materials as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.7 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. For pile foundations, stop the excavation at an elevation of from 150 to 300 mm (6 to 12 inches) above the bottom of the footing before driving piles. After pile driving has been completed, complete the remainder of the excavation to the elevations shown. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.8 GROUND SURFACE PREPARATION

3.8.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 150 mm (6 inches) before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 150 mm (6 inches), pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 300 mm (12 inches) and compact it as specified for the adjacent fill.

3.8.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.9 UTILIZATION OF EXCAVATED MATERIALS

Dispose unsatisfactory materials removing from excavations into designated waste disposal or spoil areas. Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Submit procedure and location for disposal of unused satisfactory material. Submit proposed source of borrow material. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.10 BURIED TAPE AND DETECTION WIRE

3.10.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 300 mm (12 inches) below finished grade; under pavements and slabs, bury tape 150 mm (6 inches) below top of subgrade.

3.10.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 300 mm (12 inches) above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 0.9 m (3 feet) of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.11 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials, to prevent wedging action or eccentric loading upon or against the structure. Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.11.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to .6 meters (2 feet) above the top of pipe prior to performing the required pressure tests, unless different depth is indicated on drawings. Leave the joints and couplings uncovered during the pressure test. Do not backfill the trench until all specified tests are performed.

3.11.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.11.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 150 mm (6 inches) loose thickness.

3.11.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial backfill material and compact it with approved tampers to a height of at least 300 mm (one foot) above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

a. Class I: Angular, 6 to 40 mm (0.25 to 1.5 inch), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

b. Class II: Coarse sands and gravels with maximum particle size of 40 mm (1.5 inch), including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

c. Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill as indicated.

d. Clean, coarsely graded natural gravel, crushed stone or a combination having a classification of GW GP in accordance with ASTM D2487 for bedding and backfill as indicated. The maximum particle diameter shall be one-half the lift thickness at the intended location and in no case exceed maximum particle size of 75 mm (3 inches).

3.11.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

a. Roadways, Railroads, and Airfields: Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

b. Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas: Deposit backfill in layers of a maximum of 300 mm (12 inches) loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.11.2 Backfill for Appurtenances

After the manhole, catch basin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.12 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.12.1 Gas Distribution

Excavate trenches to a depth that will provide a minimum 450 mm (18 inches) of cover in rock excavation and a minimum 600 mm (24 inches) of cover in other excavation.

3.12.2 Water Lines

Excavate trenches to a depth that provides a minimum cover of 1200 mm (4 feet) from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe. For fire protection yard mains or piping, an additional 100 mm (4 inches) of cover is required.

3.12.3 Heat Distribution System

Free initial backfill material of stones larger than 6.3 mm (1/4 inch) in any dimension.

3.12.4 Electrical Distribution System

Provide a minimum cover of 600 mm (24 inches) from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.12.5 Sewage Absorption Trenches or Pits

3.12.5.1 Porous Fill

Provide backfill material consisting of clean crushed rock or gravel having a gradation conforming to the requirements of gradation 4.75 mm (No. 4) for coarse aggregate in ASTM C33/C33M or KS F 2526.

3.12.5.2 Cover

Filter fabric, Concrete, or Kraft paper conforming to CID A-A-203, Grade B, No. 2, 22.7 kg (50 pound) weight or a layer of straw at least 50 mm (2 inches) thick as indicated.

3.12.6 Pipeline Casing

Provide new smooth wall steel pipeline casing under new, existing, railroad and pavement; in a trenchor by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated. Install pipeline casing by dry boring and jacking method as follows:

3.12.6.1 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.12.6.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.12.6.3 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight end seals as indicated. .

3.12.7 Rip-Rap Construction

Construct rip-rap on bedding material with grout in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 30 mm (0.1 foot).

3.12.7.1 Bedding Placement

Spread bedding material uniformly to a thickness of at least 75 mm 3 inches on prepared subgrade as indicated.

3.12.7.2 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above. For grouted rip-rap, hand-place surface rock with open joints to facilitate grouting and do not fill smaller spaces between surface rock with finer material. Provide at least one "weep hole" through grouted rip-rap for every 4.65 square meters (50 square feet) of finished surface. Provide weep holes with columns of bedding material, 100 mm (4 inches) in diameter, extending up to the rip-rap surface without grout.

3.12.7.3 Grouting

Prior to grouting, wet rip-rap surfaces. Grout rip-rap in successive longitudinal strips, approximately 3 m (10 feet) in width, commencing at the lowest strip and working up the slope. Distribute grout to place of final deposit and work into place between stones with brooms, spades, trowels, or vibrating equipment. Take precautions to prevent grout from penetrating bedding layer. Protect and cure surface for a minimum of 7 days.

3.13 EMBANKMENTS

3.13.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 75 mm (3 inches). Place the material in successive horizontal layers of loose material not more than 300 mm (12 inches) in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise brake up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Allowable moisture content of a lift of soil after compaction shall be within 2 percent (+/-2%) of the optimum moisture content as determined by ASTM D698.

3.13.2 Rock Embankments

Construct rock embankments from material classified as rock excavation, as defined above, placed in successive horizontal layers of loose material not more than 200 mm (8 inches) in depth. Do not use pieces of rock larger than 100 mm (4 inches) in the greatest dimension. Spread each layer of material uniformly, completely saturate, and compact to minimum density indicated in contract drawings. Adequately bond each successive layer of material to the material on which it is placed. Finish compaction with vibratory compactors weighing at least 10 metric tons (11 tons), heavy rubber-tired rollers weighing at least 10 metric tons (11 tons), or steel-wheeled rollers weighing at least 10 metric tons (11 tons). Do not use rock excavation as fill material for the construction of pavements. In embankments on which pavements are to be constructed, do not use rock above a point 900 mm (36 inches) below the surface of the pavement.

3.14 SUBGRADE PREPARATION

3.14.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a dump truck loaded with 6 cubic meters (4 cubic yards) of soil or 13.6 metric tons (15 tons), pneumatic-tired roller. Operate the roller or truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 4 to 5.5 km/hour (2-1/2 to 3-1/2 mph). When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Contracting Officer. Undercut rutting or pumping of material as indicated in contract drawings and replace with fill and backfill material.

3.14.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 150 mm (6 inches) below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 13 mm (1/2 inch) when tested with a 4 m (12-foot) straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 15 mm (0.05 foot) from the established grade and cross section.

3.14.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas and railroads, compact each layer of the embankment to at least 90 percent of laboratory maximum density.

3.14.3.1 Subgrade for Railroads

Compact subgrade for railroads to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials.

3.14.3.2 Subgrade for Pavements

Compact subgrade for pavements to at least 90 percentage laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact .

3.14.3.3 Subgrade for Shoulders

Compact subgrade for shoulders to at least 90 percentage laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials for the full depth of the shoulder.

3.14.3.4 Subgrade for Airfield Pavements

Compact top 600 mm (24 inches) below finished pavement or top 300 mm (12 inches) of subgrades, whichever is greater, to 100 percent of ASTM D1557 or KS F 2312; compact fill and backfill material to 100 percent of ASTM D1557 or KS F 2312.

3.15 SHOULDER CONSTRUCTION

Construct shoulders of satisfactory excavated or borrow material or as otherwise shown or specified.. Submit advanced notice on shoulder construction for rigid pavements. Construct shoulders immediately after adjacent paving is complete. In the case of rigid pavements, do not construct shoulders until permission of the Contracting Officer has been obtained. Compact the entire shoulder area to at least the percentage of maximum density as specified in paragraph SUBGRADE PREPARATION above, for specific ranges of depth below the surface of the shoulder. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Finish shoulder construction in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. Align the completed shoulders true to grade and shaped to drain in conformity with the cross section shown.

3.16 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 30 mm (0.1 foot) of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.16.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.16.2 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.16.3 Grading Around Structures

Construct areas within 1.5 m (5 feet) outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.17 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 50 mm (2 inches) depth for bonding of topsoil with subsoil. Spread topsoil evenly and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas.

3.18 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

a. Determine field in-place density in accordance with ASTM D1556, ASTM D2167, KS F 2311, or KS F 2347, unless otherwise indicated. .

b. ASTM D2937, use the Drive Cylinder Method only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.

c. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.18.1 Fill and Backfill Material Gradation

One test per 500 cubic meters (yards) stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C136, ASTM D422, ASTM D1140, KS F 2302, or KS F 2309.

3.18.2 In-Place Densities

a. One test per 200 square meters (2000 square feet), or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 200 square meters (2000 square feet), or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

c. One test per 200 linear meters (650 linear feet), or fraction thereof, of each lift of embankment or backfill for roads orairfields.

d. One test per 200 linear meters (650 linear feet), or fraction thereof, of each lift of embankment or backfill for railroads.

3.18.3 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer.

3.18.4 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 500 cubic meters (yards) of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. The optimum moisture content tolerance of +/- 2% is acceptable.

3.18.5 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.18.6 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to the finished grade surface, inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the Contracting Officer. Inspect pipe sizes larger than 900 mm (36 inches), while inspecting smaller diameter pipe by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Government.

3.19 DISPOSITION OF SURPLUS MATERIAL

Remove surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber from Government Property and dispose of in accordance with ROK national, provincial, and local laws.

-- End of Section --

SECTION 31 11 00

CLEARING AND GRUBBING
08/08

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Nonsaleable Materials

SD-04 Samples

Tree wound paint
Herbicide

1.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to store at the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

PART 2 PRODUCTS

2.1 TREE WOUND PAINT

Submit samples in cans with manufacturer's label of bituminous based paint of standard manufacture specially formulated for tree wounds.

2.2 HERBICIDE

Comply with Federal Insecticide, Fungicide, and Rodenticide Act (Title 7 U.S.C. Section 136) for requirements on Contractor's licensing, certification and record keeping. Contact the command Pest Control Coordinator prior to starting work. Submit samples in cans with manufacturer's label.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2 Trees, Shrubs, and Existing Facilities

Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repairs of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service.

3.2 CLEARING

Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing shall also include the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 40 mm (1-1/2 inches) or more in diameter and shall be trimmed of all branches the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 40 mm (1-1/2 inches) in diameter shall be painted with an approved tree-wound paint. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3 TREE REMOVAL

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work shall include the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Trees shall be disposed of as specified in paragraph DISPOSAL OF MATERIALS.

3.4 PRUNING

Prune trees designated to be left standing within the cleared areas of dead branches 38 mm (1-1/2 inches) or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 32 mm (1-1/4 inches) in diameter with an approved tree wound paint.

3.5 GRUBBING

Grubbing shall consist of the removal and disposal of stumps, roots larger than 75 mm (3 inches) in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to a depth of not less than 455 mm (18 inches) below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform with the original adjacent surface of the ground.

3.6 DISPOSAL OF MATERIALS

3.6.1 Saleable Timber

Consider felled timber from which saw logs, pulpwood, posts, poles, ties, or fuel wood can be produced as saleable timber. Trim limbs and tops, and saw into saleable lengths of 5 meters (16 feet) for saw logs, and stockpile adjacent to the site. The stockpile timber will remain the property of the Government.

3.6.2 Nonsaleable Materials

Written permission to dispose of such products on private property shall be filed with the Contracting Officer. Logs, stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations, except for salable timber, shall be disposed of outside the limits of Government-controlled land at the Contractor's responsibility , except when otherwise directed in writing. Such directive will state the conditions covering the disposal of such products and will also state the areas in which they may be placed.

-- End of Section --

SECTION 31 36 00

WIRE MESH GABIONS
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A313/A313M	(2010e1) Standard Specification for Stainless Steel Spring Wire
ASTM A370	(2011a) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A428/A428M	(2010) Standard Test Method for Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles
ASTM A641/A641M	(2009a; R 2014) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A764	(2007) Standard Specification for Metallic Coated Carbon Steel Wire, Coated at Size and Drawn to Size for Mechanical Springs
ASTM A809	(2008) Standard Specification for Aluminum-Coated (Aluminized) Carbon Steel Wire
ASTM A853	(2004; R 2010) Standard Specification for Steel Wire, Carbon, for General Use
ASTM A856/A856M	(2003; R 2009) Standard Specification for Zinc-5% Aluminum-Mischmetal Alloy-Coated Carbon Steel Wire
ASTM A90/A90M	(2011) Standard Test Method for Weight Mass of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM A974	(1997; R 2011) Standard Specification for Welded Wire Fabric Gabion and Gabion Mattresses (Metallic Coated or Polyvinyl Chloride (PVC) Coated)
ASTM A975	(2011) Standard Specification for Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire with

	Polyvinyl Chloride (PVC) Coating)
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM D1499	(2005) Filtered Open-Flame Carbon-Arc Type Exposures of Plastics
ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM D746	(2007) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM G152	(2013) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3552	(2008) Low Carbon Steel Wires
KS D 7011	(2002) Zinc-coated low carbon steel wires
KS D 7037	(2000) Aluminum-coated steel wire
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2526	(2007) Aggregate for Concrete
KS M 3006	(2003) DETERMINATION OF TENSILE PROPERTIES OF PLASTICS
KS M 3016	(2006) Testing method of the density and specific gravity for plastics
KS M ISO 37	(2007) Rubber, vulcanized or thermoplastic determination of tensile stress-strain properties

KS M ISO 7619-1	(2006) Rubber, vulcanized or thermoplastic determination of indentation hardness Part 1- Durometer method (Shore hardness)
KS M ISO 974	(2002) Plastics- Determination of the brittleness temperature by impact

1.2 DEFINITIONS

1.2.1 Rate of Aggressiveness

The determination of the rate of aggressiveness (non-aggressive, moderately, or highly aggressive) shall be made on a project-to-project basis, due to the many variables involved and the lack of criteria of general validity. It is normally recommended for the choice to be based on all the available data and on the experience of existing gabion structures in similar environments.

1.2.2 Double Twisted Wire Mesh Gabions

Wire mesh is classified according to the wire coating, which is applied prior to manufacturing the mesh. Coating styles are as follows:

1.2.2.1 Style 1

Wire mesh made from wire which is zinc coated before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are produced from zinc-coated wire. Style 1 for the wire coating is normally recommended for:

a. Permanent gabion structures, for works installed in non-aggressive or non-polluted environments, and this condition remains unaltered over time;

b. Temporary gabion structures, for works in moderately aggressive environments, depending on the minimum design life of the structure.

1.2.2.2 Style 2

Wire mesh made from wire which is coated with Zn-5Al-MM before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from Zn-5Al-MM coated wire. Style 2 for the wire coating is normally recommended for:

a. Permanent gabion structures, for works installed in moderately aggressive environments;

b. Temporary gabion structures, for works in aggressive environments, depending on the minimum design life of the structure.

1.2.2.3 Style 3

Wire mesh, lacing wire, and stiffeners as Style 1 and overcoated with PVC. Fasteners shall be of stainless steel wire. Style 3 for the wire coating is normally recommended for both permanent and temporary gabion structures, for works installed in aggressive or polluted environments, or when the aggressiveness of the site is moderately unpredictable or variable from low to high.

1.2.2.4 Style 4

Wire mesh made from wire which is aluminum-coated before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from aluminum-coated wire. Style 4 for the wire coating is very seldom used in the gabion industry. Its life expectancy shall be adequately documented to guarantee its consistency and reliability.

1.2.3 Welded Wire Fabric Gabions

Classified according to wire coating styles as follows:

1.2.3.1 Style 1

Welded wire fabric made from wire which is zinc coated before being welded into fabric. Spiral binders, lacing wire, and stiffeners are produced from zinc-coated wire. Style 1 for the wire coating is normally recommended for temporary gabion structures, for works in non-aggressive or non-polluted environments.

1.2.3.2 Style 2

Welded wire fabric which is made from uncoated wire and the fabric is subsequently zinc-coated after fabrication. Spiral binders, lacing wire, and stiffeners are produced from zinc-coated wire. Style 2 for the wire coating is normally recommended for permanent gabion structures, for works installed in non-aggressive or non-polluted environments, and this condition remains unchanged over time

1.2.3.3 Style 3

Welded wire fabric made from wire which is coated with zinc-5% aluminum-mischmetal alloy (Zn-5Al-MM) before being welded into fabric. Spiral binders, lacing wire, and stiffeners are also produced from zinc-5% aluminum-mischmetal alloy (Zn-5Al-MM) coated wire. Style 3 for the wire coating is normally recommended for:

a. Permanent gabion structures, for works installed in moderately aggressive environments;

b. Temporary gabion structures, for works in aggressive environments, depending on the minimum design life of the structure.

1.2.3.4 Style 4

Welded wire fabric made from wire which is aluminum-coated before being welded into fabric. Spiral binders, lacing wire, and stiffeners are also produced from aluminum-coated (aluminized) wire. Style 4 for the wire coating is very seldom used in the gabion industry. Its life expectancy shall be adequately documented to guarantee its consistency and reliability.

1.2.3.5 Style 5

Welded wire fabric, spiral binders, lacing wire, and stiffeners as Styles 1, 2, 3, or 4, and overcoated with PVC. Style 5 for the wire coating is normally recommended for both permanent and temporary gabion structures, for works installed in aggressive or polluted environments, or when the aggressiveness of the site is moderately unpredictable or variable from low to high.

1.3 SYSTEM DESCRIPTION

a. The work under this specification includes furnishing, assembling, filling and tying open wire mesh rectangular compartmented gabions placed on a prepared surface of filter material geotextile,or geotextile and filter materials, as specified, and in accordance with the lines, grades, and dimensions shown or otherwise established in the field.

b. Gabions are wire mesh containers of variable sizes, uniformly partitioned into internal cells, interconnected with other similar units, and filled with stone at the project site to form flexible, permeable, monolithic structures. Gabions shall be manufactured with all components mechanically connected at the production facility with the exception of the mattress lid, which is produced separately from the base. The supply to the jobsite of unassembled individual wire mesh components (panels) forming gabions will not be permitted.

c. Definitions of terms specific to this specification and to all materials furnished on the jobsite, with the exception of the rock to fill the baskets and the filter material, shall refer and be in compliance with ASTM A975 for double twisted wire mesh Gabions, or with ASTM A974 for welded wire fabric Gabions

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Gabions
Alternative Wire Fasteners

SD-06 Test Reports

Gabions
Alternative Wire Fasteners; G

SD-07 Certificates

Stone Fill
Filter Material

1.5 QUALITY ASSURANCE

1.5.1 Samples

Furnish samples of materials used to fabricate the gabions to the Contracting Officer 60 days prior to start of installation. Samples will be tested in accordance with specification and either ASTM A974 or ASTM A975 depending on which system is being furnished by the Contractor. The Government reserves the right to test additional samples to verify the submitted test records at the Government's expense. When the first test results indicate that the fasteners do not meet the specified requirements, the additional test will be at the Contractor's expense. The fasteners will be rejected after two tests failing to meet the requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

Gabions shall be delivered with all components mechanically connected at the production facility. All gabions and mattresses are supplied in the collapsed form, either folded or bundled or rolled, for shipping. Bundles are banded together at the factory for ease of shipping and handling. Gabions shall be delivered to the jobsite labeled in bundles. Labels shall show the dimensions of the gabions included, the number of pieces and the color code.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Double twisted wire mesh Gabions

Double twisted wire mesh gabions shall be Style 1, Style 2, Style 3, and Style 4 manufactured with a non-raveling mesh made by twisting continuous pairs of wires through three half turns (commonly called double twisted) to form a hexagonal-shaped opening. Gabion sizes, wire diameters, mesh opening sizes, and tolerances shall comply with the requirements of ASTM A975 (Tables 1, 3, 4, 5, 6, and Sections 9). Gabions shall meet the following test requirements:

a. Metallic coating - The coating weights shall conform to the requirements of ASTM A641/A641M, Class 3 (Style 1) or KS D 7011, ASTM A856/A856M (Style 2), ASTM A90/A90M or ASTM A428/A428M as applicable, and ASTM A809 (Style 4) or KS D 7037.

b. PVC for Coating - The PVC coating shall show no cracks or breaks after the wires are twisted in the fabrication of the mesh. The initial properties of PVC coating material shall have a demonstrated ability to conform to the following requirements:

   (1) Specific Gravity - In the range from 1.30 to 1.35 dN/dm3, when tested in accordance with test method ASTM D792 or KS M 3016;

   (2) Tensile Strength - Not less than 20.6 MPa (2985 psi) when tested in accordance with test method ASTM D412 or KS M ISO 37;

   (3) Modulus of Elasticity - Not less than 18.6 MPa (2700 psi) when tested in accordance with test method ASTM D412 or KS M ISO 37;

   (4) Hardness - Shore "D" between 50 and 60, when tested in accordance with test method ASTM D2240 or KS M ISO 7619-1;

   (5) Brittleness Temperature - Not higher than -5 degrees C (15 degrees F), or lower temperature when specified by the purchaser, when tested in accordance with test method ASTM D746 or KS M ISO 974.

   (6) Resistance to Abrasion - The percentage of the weight loss shall be less than 12%;

(7) Salt Spray Exposure and Ultra Violet Light Exposure - The PVC shall show no effect after 3,000 h of salt spray exposure in accordance with ASTM B117. The PVC shall show no effect of exposure to ultra violet light with test exposure of 3,000 h, using apparatus Spectral Irradiance of Open Flame Carbon Arc with Daylight Filters and 63 degrees C (145 degrees F), when tested in accordance with practice ASTM D1499 and ASTM G152;

(8) Evaluation of Coating After Salt Spray and Ultraviolet Exposure Test - After the salt spray test and exposure to ultraviolet light, the PVC coating shall not show cracks, noticeable change of color, blisters or splits. In addition, the specific gravity, tensile strength, hardness and resistance to abrasion shall not change more than 6%, 25%, and 10% respectively, from their initial values.

c. Wire Tensile Strength - The tensile strength of the wire used for the double twisted mesh, lacing wire, and stiffener, when tested in accordance with Test Methods and definitions ASTM A370, shall be in accordance with the requirements of ASTM A641/A641M (Style 1) or KS D 7011, ASTM A809 (Style 4) or KS D 7037, and ASTM A856/A856M (Style 2), for soft temper wire.

d. Mesh strength and panel to panel joint strength - The minimum strength requirements of the mesh, selvedge wire to mesh connection, panel to panel connection, and punch test, when tested in accordance with ASTM A975 Section 13.1, shall be as shown in Table 1. The strength values reported in kN/m (lb/ft) are referred to the unitary width of the specimen. The panel to panel test shall demonstrate the ability of the fastening system to achieve the required strength, and indicate the number of wire revolutions for the lacing wire or the ring spacing for ring fasteners used. The same number of wire revolutions or ring spacing shall be used in the field installation. Pleating the based panel to obtain internal panels is prohibited.

TABLE 1

Minimum Strength Requirements of Mesh and Connections

Test description	Gabions, metallic coated kN/m	Gabions, PVC coated kN/m
Tensile strength parallel to twist	51.1	42.3
Tensile strength perpendicular to twist	26.3	20.4
Connection to selvedges	20.4	17.5
Panel to panel (using lacing wire or ring fasteners)	20.4	17.5

Test description	Gabions, metallic coated kN	Gabions, PVC coated kN
Punch Test	26.7	23.6

TABLE 1

Minimum Strength Requirements of Mesh and Connections

Test description	Gabions, metallic coated lb/ft	Gabions, PVC coated lb/ft
Tensile strength parallel to twist	3500	2900
Tensile strength perpendicular to twist	1800	1400
Connection to selvedges	1400	1200
Panel to panel (using lacing wire or ring fasteners	1400	1200

Test description	Gabions, metallic coated lb	Gabions, PVC coated lb
Punch Test	6000	5300

2.1.2 Welded Wire Fabric Gabions

Welded wire fabric gabions shall be Style 1, Style 2, Style 3, Style 4,or Style 5 manufactured with a welded wire mesh composed of a series of longitudinal and transverse steel wires arranged substantially at right angles to each other, and welded together at the points of intersection by electrical resistance welding to form fabricated sheets. Gabion sizes, wire diameters, mesh opening sizes, physical properties of the PVC for coating, and tolerances shall comply with the requirements of ASTM A974 (Tables 1, 2, 3, and Sections 9). Gabions shall meet the following test requirements:

a. Metallic coating - The coating weights shall conform to the requirements of ASTM A641/A641M, Class 3 (Style 1) or KS D 7011, ASTM A856/A856M (Style 2), ASTM A90/A90M or ASTM A428/A428M as applicable, and ASTM A809 (Style 4)or KS D 7037.

b. PVC for Coating - PVC adhesion test shall be PVC coating shall show no cracks or breaks after the wires are twisted in the fabrication of the mesh. The initial properties of the PVC coating on the wire and welded wire fabric shall have a demonstrated ability to conform to the following requirements:

(1) Adhesion - The PVC coating shall adhere to the wire such that the coating breaks rather than separates from the wire, in accordance with test method ASTM A974 Section 13.3;

(2) Mandrel bend - The PVC-coated wire when subjected to a single 360 bend at -18 degrees C (0 degrees F) around a mandrel ten times the diameter of the wire, shall not exhibit breaks or cracks in the PVC coating;

(3) Specific Gravity - In the range from 1.20 to 1.40 dN/dm3, when tested in accordance with test method ASTM D792 or KS M 3016;

(4) Tensile Strength - Not less than 15.7 MPa (2275 psi) when tested in accordance with test method ASTM D638 or KS M 3006;

(5) Modulus of Elasticity - Not less than 13.7 MPa (1980 psi) at 100% strain, when tested in accordance with test method ASTM D638 or KS M 3006;

(6) Hardness - Shore "A" not less than 75, when tested in accordance with test method ASTM D2240 or KS M ISO 7619-1;

(7) Brittleness Temperature - Not higher than -9 degrees C (15 degrees F), or lower temperature when specified by the purchaser, when tested in accordance with test method ASTM D746 or KS M ISO 974.

(8) Resistance to Abrasion - The percentage of the weight loss shall be less than 12%;

(9) Salt Spray Exposure and Ultra Violet Light Exposure - The PVC shall show no effect after 3,000 h of salt spray exposure in accordance with ASTM B117. The PVC shall show no effect of exposure to ultra violet light with test exposure of 3,000 h, using apparatus Spectral Irradiance of Open Flame Carbon Arc with Daylight Filters and 63 degrees C (145 degrees) F, when tested in accordance with practice ASTM D1499 and ASTM G152;

(10) Evaluation of Coating After Salt Spray and Ultraviolet Exposure Test - After the salt spray test and exposure to ultraviolet light, the PVC coating shall not show cracks, noticeable change of color, blisters or splits. In addition, the specific gravity, tensile strength, hardness and resistance to abrasion shall not change more than 6%, 25%, and 10% respectively, from their initial values.

c. Wire Tensile strength - The tensile strength of the wire used for the welded wire fabric, spiral binders, lacing wire and stiffeners shall be soft medium in accordance with ASTM A641/A641M (Style 1) or KS D 7011, ASTM A856/A856M (Style 3), and ASTM A809 (Style 4) or KS D 7037, or hand drawn in accordance with ASTM A853 (Style 2) or KS D 3552. The cross-sectional area of the test specimen shall be based on the diameter of the metallic coated wire. All the wires used in the fabrication of gabions must use the same temper wire in accordance with given order.

d. Weld Shear Strength - The minimum average shear value in Newtons (pounds-force) shall be 70% of the breaking strength of the wire or as indicated in the table as follows, whichever is greater, when tested in accordance with ASTM A974 Section 13.4. Typical minimum average shear strengths as specified are as follows:

TABLE 2

Minimum average shear strength values for the welded mesh

Wire Diameter mm	Min. Av. Shear Strength N	Min. Shear Strength N
2.20	1300	1000
2.70	2100	1600
3.05	2600	2000

TABLE 2

Minimum average shear strength values for the welded mesh

Wire Diameter inch	Min. Av. Shear Strength lbs	Min. Shear Strength lbs
0.087	292	225
0.106	472	360
0.120	584	450

The material shall be deemed to conform with the requirements for weld shear strength if the average of the test results of the first four specimens or if the average of the test results for all welds tested comply with TABLE 2.

Panel to Panel Joint Strength - The minimum strength of the joined panels, when tested as described in ASTM A974 Section 13.5, shall be as follows:

TABLE 3

Panel to panel joint strength for welded gabions

Test Description	Gabions, Metallic coated kN/m	Gabions, PVC coated kN/m	
Connection to selvedges	20.4	17.5	10.2
Panel to panel (using lacing wire or ring fasteners	20.4	17.5	10.2

TABLE 3

Panel to panel joint strength for welded gabions

Test Description	Gabions, Metallic coated lb/ft	Gabions, PVC coated lb/ft	
Connection to selvedges	1400	1200	700
Panel to panel (using lacing wire or ring fasteners	1400	1200	700

The strength values reported in kN/m (lb/ft) are referred to the unitary width of the specimen. The panel to panel test shall demonstrate the ability of the fastening system to achieve the required strength, and indicate the number of wire revolutions for the lacing wire used. The same number of wire revolutions shall be used in the field installation.

2.1.3 Alternative Wire Fasteners for Gabions

Subject to approval of the Contracting Officer, alternative fastening systems may be used in lieu of lacing wire. Alternative fasteners to lacing wire recommended for woven wire gabions , according to ASTM A975, are steel ring fasteners for metallic coated gabions , or stainless steel rings for PVC coated gabions. For each shipment of wire gabions delivered to the site, furnish the Contracting Officer, in duplicate, test reports or records that have been performed during the last year on all material contained within the shipment meets the composition, physical, and manufacturing requirements stated in this specification. Ring fasteners for woven wire gabions shall comply with the minimum requirements indicated in paragraph Ring Fasteners below, and they shall develop a minimum panel to panel joint strength as indicated in TABLE 1. Alternative fasteners to lacing wire for welded wire gabions and mattresses, according to ASTM A974, are spiral binders. Spiral binders for welded wire gabions and mattresses shall comply with the minimum requirements indicated in paragraph Spiral Binders below. Ring fasteners may alternatively be used for welded wire gabions or mattresses, provided that they comply with the minimum specified requirements (salt spray and pull-apart resistance). Connections panel to panel for welded gabions and mattresses with ring fasteners shall develop a minimum joint strength as indicated in TABLE 3. Provide a complete description of the fastener system and a description of a properly installed fastener, including drawings or photographs if necessary. Provide test results that demonstrate that the alternative-fastening system meets the requirements of the specifications, according to the following criteria:

a. That the proposed fastener system can consistently produce a panel to panel joint strength as indicated in the TABLE 1 for double twisted wire mesh gabions and TABLE 3 for welded wire mesh gabions;

b. That the proposed fastener system does not cause damage to the protective coating on the wire;

c. That the Contractor has the proper equipment and trained employees to correctly install the fasteners;

d. That proper installation can be readily verified by visual inspection.

Samples of wire fasteners with their certified test records shall be submitted at least 60 days in advance to the Contracting Officer for approval. The Government reserves the right to test additional samples to verify the submitted test records . When the first test results indicate that the fasteners do not meet the specified requirements, the additional test will be at the Contractor's expense. The fasteners will be rejected after two tests failing to meet the requirements.

2.1.3.1 Ring Fasteners

The tensile strength of the zinc-coated steel wire, zinc-5% aluminum coated mischmetal alloy-coated steel wire and aluminum-coated steel wire used for fasteners shall be in accordance with the requirements of ASTM A764, Type A, B, or C, Table 2 or Table 3. The tensile strength of stainless steel wire used for fasteners shall be in accordance with the requirements of ASTM A313/A313M, Type 302, Table 2. Any fastener system shall give the number of fasteners required to comply with TABLE 1, in accordance with ASTM A975 (Section 13.1.2) for woven wire gabions , and TABLE 3, in accordance with ASTM A974 (Section 7.3), for welded wire gabions. Ring fasteners shall not be installed more than 100 mm (4 inches) apart. Each fastener type shall be closed and the free ends of the fastener shall overlap a minimum of 25 mm (1 inch). The manufacturer or supplier shall state the number of fasteners required for all vertical and horizontal connections for single and multiple basket joining. Approved ring fasteners including fasteners made of stainless steel shall be subject to the salt spray test and pull-apart resistance test and shall be documented by actual testing of panel to panel connections within the last year by validated laboratories.

a. Salt Spray Test - A set of two identical rectangular gabion panels, each with a width about 10-1/2 mesh openings along a selvedge wire, shall be joined by properly installed wire fasteners along the two selvedge wires so that each fastener confines two selvedge and two mesh wires. If the fasteners are also to be used to joint two individual empty gabion baskets, two additional selvedge wires which are each mechanically wrapped with mesh wires shall be included so that each fastener confines four selvedge and four mesh wires. The set of the jointed panels shall be subject to salt spray test, ASTM B117, for a period of not less than 48 hours. At the end of the test, the fasteners, the selvedge, or mesh wires confined by the fasteners shall show no rusty spots on any part of the surface excluding the cut ends. A properly installed fastener shall meet the following requirements:

   (1) Each interlocking fastener shall be in a locked and closed position.

   (2) Each ring fastener shall be closed, and the free ends of the fastener shall overlap a minimum of 25 mm (1 inch).

b. Pull-Apart Resistance Test - A new set of the jointed panels, which are prepared by the same method as specified in the salt spray test but without being subject to the 48-hour salt spray test, shall be mounted on a loading machine with grips or clamps such that the panels are uniformly secured along the full width. The grips or clamps shall be designed to transmit only tension forces. The load will then be applied at a uniform rate of 220 N/s (50 lbs/sec) until failure occurs. The failure is defined as when the maximum load is reached and a drop of strength is observed with subsequent loading or the opening between any two closest selvedge wires, applicable to a fastener confining either two or four selvedge wires, becomes greater than 50 mm (2 inches) at any place along the panel width. The strength of the jointed panels at failure shall have a minimum as indicated in TABLE 1 or TABLE 3.

2.1.3.2 Spiral Binders

Spiral binders are defined as a length of metallic coated steel wire or metallic coated steel wire with PVC coating preformed into a spiral, used to assemble and interconnect empty gabion units, and to close and secure stone-filled units. Spiral binders shall be fabricated with the same wire and coating style as the wire mesh. Test requirements for spiral binders shall refer to TABLE 3 regarding Metallic Coating, PVC for coating, Tensile Strength, and Panel to Panel Joint Strength.

2.1.4 Testing

Test records made within one year by certified laboratories and Government agencies will be used to determine the acceptability of the fastening system. Samples of wire fasteners and samples of material for fabricating the gabions with their certified test records shall be submitted at least 60 days in advance to the Contracting Officer for approval. The Government reserves the right to test additional samples to verify the submitted test records at the Government's expense. When the first test results indicate that the fasteners do not meet the specified requirements, the additional test will be at the Contractor's expense. The fasteners will be rejected after two tests failing to meet the requirements.

2.1.5 Stone Fill

Submit a certificate or affidavit signed by a legally authorized official of the supplier of the stone fill and the supplier of the natural filter material (se next main paragraph below) that it meets the quality required and gradation limits specified.

2.1.5.1 General

For gabions, the ability to function properly depends upon their stability, which is partly depending upon the rocks filling them. Rock sizes should be chosen to prevent them from falling through the mesh of the gabions . The rock has also to withstand natural weathering processes during the life of the project that would cause it to breakdown to sizes smaller than the wire mesh opening dimensions. Rock to fill gabions shall be durable and of suitable quality to ensure permanence in the structure and climate in which it is to be used.

a. Delivery. Rock shall be delivered to the work site in a manner to minimize its reduction in sizes (breakdown) during the handling of the rock, and be placed and secured within the assembled and interconnected gabion.

b. Sources. The sources from which the Contractor proposes to obtain the material shall be selected well in advance of the time when the material will be required in the work. The inclusion of more than 5% by weight of dirt, sand, clay, and rock fines will not be permitted. Rock may be of a natural deposit of the required sizes, or may be crushed rock produced by any suitable method and by the use of any device that yields the required size limits chosen in TABLE 4.

c. Properties. Rocks shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during the life of the structure.

d. Non-listed Source. The Contractor may, as an option, propose to furnish stone from one non-listed source. The Government may make such investigations and tests as necessary to determine whether acceptable stone can be produced from the proposed source. Suitable samples of stone fill material shall be collected in the presence of a Government representative and submitted to the Contracting Officer for approval prior to delivery of any such material to the work site. Unless otherwise specified, all test samples shall be obtained and delivered at the Contractor's expense at least 60 days in advance of the time when placing of the stone-filled gabions is expected to begin. Suitable tests and/or service records will be used to determine the acceptability of the stone. In the event suitable test reports and service records are not available, as in the case of newly operated sources, the material may be subjected to petrography analysis, specific gravity, absorption, wetting and drying, freezing and thawing, and such other tests as may be considered necessary to demonstrate to the satisfaction of the Contracting Officer that the materials are acceptable for use in the work. All tests will be made by or under the supervision of the Government and at its expense.

2.1.5.2 Stone Quality

Stone fill, crushed stone, shall meet the quality requirements of ASTM C33/C33M or KS F 2526,.

2.1.5.3 Gradation

Gradation of stone for gabions shall be performed every 1000 metric tons placed under this contract in accordance with ASTM C136 or KS F 2502. Sizes of rock to fill gabions are chosen on the basis of the mesh sizes, the structure's thickness, and within the limits shown in TABLE 4. Within each range of sizes, the rock shall be large enough to prevent individual pieces from passing through the mesh openings. Each range of sizes may allow for a variation of 5% oversize rock by weight, or 5% undersize rock by weight, or both.

a. Oversize Rock. In all cases, the sizes of any oversize rock shall allow for the placement of three or more layers of rock within each gabion compartment.

b. Undersize Rock. In all cases, undersize rock shall be placed within the interior of the gabion compartment and shall not be placed on the exposed surface of the structure. There shall be a maximum limit of 5% undersize or 5% oversize rock, or both, within each gabion compartment. The required rock gradation is reported in Table 4.

TABLE 4

Required rock gradation for gabions

Type of structure	Thickness (height) m	Rock sizes mm
Gabions	0.30	100 - 200
Gabions	0.50 or higher	100 - 200

TABLE 4

Required rock gradation for gabions

Type of structure	Thickness (height) inch	Rock sizes inch
Gabions	12	4 - 8
Gabions	18 or higher	4 - 8

2.1.6 Filter Material

The material shall meet the quality requirements of ASTM C33/C33M or KS F 2526 for the region in which the structure is located. The gradation test shall be performed in accordance with ASTM C136 or KS F 2502. Filter material shall consist of sand and gravel or crushed stone, well graded.

PART 3 EXECUTION

3.1 FOUNDATION PREPARATION

Foundation preparation shall not take place on frozen or snow-covered ground. After excavation or stripping, to the extent indicated on the drawings or as directed by the Contracting Officer, all remaining loose or otherwise unsuitable materials shall be removed. All depressions shall be carefully backfilled to grade. If pervious materials are encountered in the foundation depressions, the areas shall be backfilled with free-draining materials. Otherwise, the depressions shall be backfilled with suitable materials from adjacent required excavation, or other approved source, and compacted to a density at least equal to that of the adjacent foundation. Any debris that will impede the proper installation and final appearance of the gabion layer shall also be removed, and the voids carefully backfilled and compacted as specified above. Immediately prior to placing the material, the Contracting Officer shall inspect the prepared foundation surface, and no material shall be placed thereon until that area has been approved.

3.2 FILTER PLACEMENT

Filter material shall be spread uniformly on the prepared foundation surface in a manner satisfactory to the Contracting Officer, and to the slopes, lines, and grades as indicated on the drawings or as directed. Placing of filter material by methods, which will tend to segregate particle sizes, will not be permitted. Any damage to the foundation surface during the filter placement shall be repaired before proceeding with the work. Compaction of the filter materials will not be required, but it shall be finished to present a reasonably even surface free from mounds or windrows.

3.3 ASSEMBLY

3.3.1 Double twisted wire mesh Gabions

The gabions shall be opened and unfolded one by one on a flat, hard surface. Gabion units over 1.82 m (6 feet) in length usually have an extra shipping fold, which must be removed. The sides, ends and diaphragms shall be lifted up into a vertical position to form an open box shape. The back and the front panels of the gabion shall be connected to the end panels and center diaphragms. The top corner of the end panels and center diaphragms have a selvedge wire extending approximately 100 mm (4 inches) out from the corner edge. The end panels and the diaphragms shall be raised to a vertical position and the selvedge wire shall be wrapped around the edge wire of the top and back panels.

3.3.2 Welded Wire Fabric Gabions

The gabions shall be opened and unfolded on a flat, hard surface. The units shall be rotated into position and the edges joined with fasteners for assembly. Where spiral fasteners are used, the ends shall be crimped to secure them in place. Where lacing wire is used, the wire shall be wrapped with alternating double and single loops with spacings not to exceed 150 mm (6 inches). Ends shall be secured with two complete revolutions and finished with a one-half hitch. The same fastening procedures shall be used to secure interior diaphragms and end panels. When two gabions are placed side by side, the two end panels may be connected along the vertical edges with a single spiral fastener.

3.4 LACING OPERATIONS

3.4.1 Double Twisted Wire Mesh Gabions

Either lacing wire or ring fasteners are permitted to lace double twisted wire mesh gabions.

a. When using lacing wire, a piece of wire 1.2 to 1.5 times the length of the edge to be laced shall be cut off. If the edge of the basket is

0.91 m (3 foot) long, no more than 1.2 to 1.5 m (4 to 5 feet) of wire should be used at a time to lace. For vertical joints, starting at the bottom end of the panel, the lacing wire shall be twisted and wrapped two times around the bottom selvedge and double and single loops shall be alternated through at intervals not bigger than 100 to 150 mm (4 to 6 inches). The operation shall be finished by looping around the top selvedge wire. The use of pliers to assemble the units with lacing wire is normally recommended.

b. When steel wire ring fasteners are used, the rings shall be installed at the top and bottom connections of the end and center diaphragms. The ring spacing shall be based on the minimum pull apart strength as specified in TABLE 1. In any case, the maximum ring spacing along the edges shall not exceed 0.15 m (6 inches). The use of either a mechanical or a pneumatic fastening tool for steel wire ring fasteners is required. Ring fasteners shall be galvanized, stainless steel or Zn-5% aluminum-mischmetal alloy coated.

3.4.2 Welded Wire Mesh Gabions

Either lacing wire or spiral binders are permitted to lace welded wire mesh gabions. The empty units shall be placed on the foundation and interconnected with the adjacent unit along the top, bottom and vertical edges using spiral fasteners. Lacing wire may be used in lieu of spiral binders for the interconnection of gabions as specified above. The connection with lacing wire or spiral binders shall be based on the minimum panel to panel joint strength as specified in TABLE 3. Spiral binders shall be screwed along the connecting edges, and then each end crimped to secure the spiral in place. Each layer of gabions shall be interconnected to the underlying layer along the front, back and sides.

3.5 INSTALLATION AND FILLING

Empty gabion units shall be assembled individually and placed on the approved surface to the lines and grades as shown or as directed, with the sides, ends, and diaphragms erected in such a manner to ensure the correct position of all creases and that the tops of all sides are level. All gabion units shall be properly staggered horizontally and vertically as shown in the construction drawings. Finished gabion or mattress structures shall have no gaps along the perimeter of the contact surfaces between adjoining units. All adjoining empty gabion units shall be connected along the perimeter of their contact surfaces in order to obtain a monolithic structure. All lacing wire terminals shall be securely fastened. All joining shall be made through selvedge-to-selvedge or selvedge-to-edge wire connection; mesh-to-mesh or selvedge-to-mesh wire connection is prohibited except in the case where baskets are offset or stacked and selvedge-to-mesh or mesh-to-mesh wire connection would be necessary. As a minimum, a fastener shall be installed at each mesh opening at the location where mesh wire meets selvedge or edge wire.

a. The initial line of basket units shall be placed on the prepared filter layer surface and adjoining empty baskets set to line and grade, and common sides with adjacent units thoroughly laced or fastened. They shall be placed in a manner to remove any kinks from the mesh and to a uniform alignment. The basket units then shall be partially filled to provide anchorage against deformation and displacement during the filling operation. The stone shall be placed in the units as specified in paragraph Stone Fill, subparagraph Gradation, part b.

b. Undue deformation and bulging of the mesh shall be corrected prior to further stone filling. Care shall be taken, when placing the stone by hand or machine, to assure that the PVC coating on gabions will not be damaged. All visible faces shall be filled with some hand placement to ensure a neat and compact appearance and that the void ratio is kept to a minimum.

c. Gabions shall be uniformly overfilled by about 25 to 50 mm (1 to 2 inches) to compensate for future rock settlements. Gabions can be filled by any kind of earth-filling equipment, such as a backhoe, gradall, crane, etc. The maximum height from which the stones may be dropped into the baskets shall be 0.91 to 1.20 m (3 to 4 feet). If PVC coated materials are used, no work shall take place unless the ambient temperature is above -7 degrees C (20 degrees F).

3.5.1 Double Twisted Wire Mesh Gabions

After the foundation has been prepared, the pre-assembled gabions shall be placed in their proper location to form the structure. Gabions shall be connected together and aligned before filling the baskets with rock. All connections (panel-to-panel) and basket-to-basket shall be already carried out as described in paragraph ASSEMBLY. Stone fill shall have a gradation of 0.10 to 0.20 m (4 to 8 inches), as described in paragraph Gradation, and shall be placed in 0.30 m (1 foot) lifts. Cells shall be filled to a depth not exceeding 0.30 m (1 foot) at a time. The fill layer should never be more than 0.30 m (1 foot) higher than any adjoining cell. Stiffeners or internal cross ties shall be installed in all front and side of the gabions at 1/3 and 2/3 of the height for 0.91 m (3 feet) or higher gabions, as the cell is being filled. Stiffeners shall be installed in the center of the cells. In 0.46 m (1.5 foot) high units, stiffeners or internal crossties are not required. Internal cross ties, or alternatively the preformed stiffeners, shall be looped around three twisted wire mesh openings at each basket face and the wire terminals shall be securely twisted to prevent their loosening. The number of voids shall be minimized by using a well-graded stone in order to achieve a dense, compact stone fill. All corners shall be securely connected to the neighboring baskets of the same layer before filling the units. When more than one layer of gabions is required, in order for the individual units to become incorporated into one continuous structure, the next layer of gabions shall be connected to the layer underneath after this layer has been securely closed. Gabions shall be uniformly overfilled by about 25 to 50 mm (1 to 2 inches) to compensate for future rock settlements.

3.5.2 Welded Wire Fabric Gabions

After the foundation has been leveled, the assembled gabions shall be placed in their proper location to form the structure. Care shall be taken to ensure that the top of the diaphragms are aligned correctly. The diaphragms shall be securely connected by either spiral binders or lacing wire. Gabions shall be connected together and aligned before filling them with 100 to 200 mm (4 to 8 inch) diameter rocks. Rock filling material shall be as specified in paragraph Gradation and shall be placed in 0.30 m (1 foot) lifts. The fill layer shall be carefully hand-packed and braced to prevent bulging. Stiffeners shall be provided every 0.30 m (12 inch) levels for 0.91 m (3 foot) or higher gabions. Stiffeners shall be formed from lacing wire and placed across the corners at 0.30 m (12 inches) from the corner, providing a diagonal bracing. Preformed hooked stiffeners can be utilized. Care shall be taken to ensure the number of voids is minimized by using a well-graded stone and avoiding large rocks in order to achieve a dense, compact compartment. After each 0.30 m (1 foot) lift has been placed, it shall be leveled for the next lift. Almost all gabion structures consist of more than one course of gabions; in order that the individual gabions may become incorporated into one continuous structure, they shall be wired to neighboring gabions and the course below, before filling. Gabions shall be uniformly overfilled by about 25 to 50 mm (1 to 2 inches) to compensate for future rock settlements.

3.5.3 Non-Rectangular Shapes

Gabion units can conform to bends up to a radius of curvature of 18 to 21 m (60 to 70 feet) without alterations. Units shall be securely connected together first, and be placed to the required curvature, holding them in position by staking the units to the ground with hardwood pegs before filling. For other shapes, bevels and miters can be easily formed by cutting and folding the panels to the required angles.

3.6 CLOSING

Lids shall be tightly secured along all edges, ends and diaphragms in the same manner as described for assembling. Adjacent lids may be securely attached simultaneously. The panel edges shall be pulled to be connected using the appropriate closing tools where necessary. Single point leverage tools, such as crowbars, may damage the wire mesh and shall not be used. All end wires shall then be turned in.

-- End of Section --

SECTION 32 01 11.51

RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Rubberandpaint removal samples

SD-07 Certificates

Schedule of work

High-pressure rubber and paint removal equipment

1.3 RADIO COMMUNICATION

No personnel or equipment will be allowed on the runway until radio contact has been made with the Control Tower and permission is granted by the Control Tower. A radio for this purpose will be made available by the Contracting Officer. The Contractor shall be in contact with the Control Tower at all times during the removal work.

1.4 EMERGENCY LANDINGS AND TAKEOFF

Emergencies shall take precedence over all Contractor operations. Upon notification from the Control Tower of emergency landing or imminent takeoff, all operations shall be stopped immediately and all personnel and equipment evacuated to an area not utilized for aircraft traffic which is at least 60 m (200 feet) measured perpendicular to and away from the near edge of the runway. Equipment shall be able to clear the work area within 3 minutes.

1.5 ENVIRONMENTAL CONDITIONS

Do not perform work when the temperature is below 5 degrees C (40 degrees F), during lightning storms, or when the pavement is covered with snow or ice.

1.6 SAFETY

Comply with OSHA 29 CFR 1910.

1.7 SCHEDULE

1.7.1 Schedule of Work

Submit a schedule of work to the Contracting Officer for transmittal to the Operations Officer. Describe the work to be accomplished; noting the location of work, distances from the ends of runways, taxiways, buildings, and other structures; and indicating dates and hours during which the work will be accomplished. Schedule the work to conform to aircraft operating schedules. The Government will try to schedule aircraft operations so as to permit the maximum amount of time for the Contractor's work. However, in the event of any emergency, intense operational demands, adverse wind conditions, and other unforeseen difficulties, discontinue all work at locations in the aircraft operational area. Keep the approved schedule of work current and notify the Contracting Officer of any changes prior to beginning each day's work.

1.8 EQUIPMENT

1.8.1 Equipment Data

Submit descriptive data of high-pressure rubber and paint removal equipment including area of coverage per pass, range of water pressures, and water tank capacity.

1.9 QUALITY ASSURANCE

1.9.1 Required Samples

Prior to the start of work, remove rubberandpaint on designated test areas not less than 15 m (50 feet) in length. Use procedures, water pressures, nozzle height, nozzle spacings, nozzle angle, and equipment movement rate to achieve the required degree of rubber and paint removal in accordance with the paragraph entitled "Execution." Submit the test results before any further removal work will be allowed.

PART 2 PRODUCTS

2.1 MATERIALS

Water to be used for high-pressure water equipment will be made available from Government hydrants as shown on the drawingsat no cost to the Contractor. Furnish all equipment and labor for delivery of water from the hydrant to the job site. Notify the Contracting Officer on location of fire hydrants to be used and the respective times of use. Connections to a fire hydrant will be subject to the Contracting Officer's inspection and approval.

2.2 EQUIPMENT

Vehicular-mounted hydraulic system capable of delivering high-pressure water impact upon the pavement surface less or greater than 55 MPa (8,000 pounds per square inches). If high-pressure water is delivered from a spray bar, the nozzles shall be spaced to provide total coverage of the area being treated. The nozzle line shall have adjustable pressure regulators or relief valves and gauges measuring actual line pressure. Equipment shall be supported on pneumatic tires. Provide equipment, tools, and machinery which are safe and in satisfactory condition at all times.

PART 3 EXECUTION

3.1 DEGREE OF REMOVAL

Remove 90 percent of all visible rubber from Portland cement concrete pavements and 85 percent of all visible rubber from asphaltic concrete pavements.Remove percent of 80 loose, flaking paint. Hard, firm paint that has the surface chalk removed may remain.

3.2 RATE OF REMOVAL

Remove rubber at a minimum rate of 900 square meters per hour (10,000 square feet per hour).Remove paint at a minimum rate of 90.0 square meters per hour (1,000 square feet per hour). Do not permit high-pressure water application to remove the existing pavement surface.

3.3 WATER PRESSURE

Provide water pressure impact upon the indicated pavement areas sufficient to remove the designated rubberandpaint to the required degree of removal without damaging the existing pavement joint sealant, and other airfield appurtenances. Contractor shall be responsible for repairing any damage caused by the removal work.

3.4 REMOVAL OF RESIDUE

Remove all residue from the pavement. Obtain the approval of residue removal and disposal method from the Contracting Officer prior to beginning work.

-- End of Section --

SECTION 32 01 16.17

COLD MILLING OF BITUMINOUS PAVEMENTS

PART 1 GENERAL

1.1 SYSTEM DESCRIPTION

Maintain in a satisfactory working condition equipment, tools, and machines used in the performance of the work.

1.1.1 Cold-Milling Machine

Provide a cold-milling machine which is self-propelled, capable of milling the pavement to a specified depth and smoothness and of establishing grade control; with means of controlling transverse slope and dust produced during the pavement milling operation. The machine shall have the ability to windrow the millings or cuttings or remove the millings or cuttings from the pavement and load them into a truck. The milling machine shall not cause damage to any part of the pavement structure that is not to be removed.

1.1.2 Cleaning Equipment

Provide cleaning equipment suitable for removing and cleaning loose material from the pavement surface.

1.1.3 Straightedge

Furnish and maintain at the site, in good condition, one 3.6 meters (12 feet) straightedge or other suitable device for each milling machine, for testing the finished surface. Make straightedge available for Government use. Straightedges shall be constructed of aluminum or other lightweight metal, with blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Straightedges shall have handles to facilitate movement on the pavement.

1.2 QUALITY ASSURANCE

1.2.1 Grade

Conform the finished milled surfaces to the lines, grades, and cross sections indicated. The finished milled-pavement surfaces shall vary not more than 0mm 6 mm (0 inch 1/4 inch) from the established plan grade line and elevation. Finished surfaces at a juncture with other pavements shall coincide with the finished surfaces of the abutting pavements. The deviations from the plan grade line and elevation will not be permitted in areas of pavements where closer conformance with planned grade and elevation is required for the proper functioning of appurtenant structures involved.

1.2.2 Surface Smoothness

Finished surfaces shall not deviate from the testing edge of a straightedge more than 6 mm (1/4 inch) in the transverse or longitudinal direction.

1.2.3 Traffic Control

Provide all necessary traffic controls during milling operations.

1.3 ENVIRONMENTAL REQUIREMENTS

Milling shall not be performed when there is accumulation of snow or ice on the pavement surface.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Clean the pavement surface of excessive dirt, clay, or other foreign material immediately prior to milling the pavement.

3.2 MILLING OPERATION

A minimum of seven days notice is required, prior to start work, for the Contracting Officer to coordinate the milling operation with other activities at the site. Make sufficient passes so that the designated area is milled to the grades and cross sections indicated. The milling shall proceed with care and in depth increments that will not damage the pavement below the designated finished grade. Repair or replace, as directed, items damaged during milling such as manholes, valve boxes, utility lines, pavement that is torn, cracked, gouged, broken, or undercut. The milled material shall be removed from the pavement and loaded into trucks.

3.3 GRADE AND SURFACE-SMOOTHNESS TESTING

3.3.1 Grade-Conformance Tests

Test the finished milled surface of the pavement for conformance with the plan-grade requirements and for acceptance by the Contracting Officer by running lines of levels at intervals of 7.5 meters (25 feet) longitudinally and 7.5 meters (25 feet) transversely to determine the elevation of the completed pavement. Correct variations from the designated grade line and elevation in excess of the plan-grade requirements as directed. Skin patching for correcting low areas will not be permitted. Remove and replace the deficient low area. Remove sufficient material to allow at least 25 mm (1 inch) of asphalt concrete to be placed.

3.3.2 Surface-Smoothness Tests

After completion of the final milling, the finished milled surface will be tested by the Government with a straightedge. Other approved devices may be used, provided that when satisfactorily and properly operated, such devices reveal all surface irregularities exceeding the tolerances specified. Correct surface irregularities that depart from the testing edge by more than 6 mm (1/4 inch). Skin patching for correcting low areas will not be permitted. Remove and replace the deficient low area. Remove sufficient material to allow at least 25 mm (1 inch) of asphalt concrete to be placed.

3.4 REMOVAL OF MILLED MATERIAL

Material that is removed shall be placed in the disposal area as specifiedby the Contracting Officer.

-- End of Section --

SECTION 32 01 17.16

SEALING OF CRACKS IN BITUMINOUS PAVEMENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C509	(2006; R 2011) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D6690	(2012) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D789	(2007; E 2010) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2368	(2006) Testing method for sealant and filler, hot-applied, for joints and cracks in asphaltic and portland cement concrete pavements

1.2 SYSTEM DESCRIPTION

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

1.2.1 Routing Equipment

Provide routing equipment which is a self-powered machine operating a power driven tool or bit specifically designed for routing bituminous pavements. The bit shall rotate about a vertical axis at sufficient speed to cut a smooth vertical-walled reservoir in the pavement surface and shall maintain accurate cutting without damaging the sides or top edges of the reservoir. Provide a router capable of following the trace of the crack without deviation. The use of rotary impact routing devices will not be permitted for cleaning cracks.It may be permitted if vertical-sided carbide tipped bits are used.

1.2.2 Concrete Saw

Provide a self-propelled power saw with small diameter (152 mm (6 inches) or less) water-cooled diamond or abrasive saw blades for cutting cracks to the depths and widths specified and for removing filler that is embedded in the cracks or adhered to the crack faces. The diameter of the saw blade shall be small enough to allow the saw to closely follow the trace of the crack.

1.2.3 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary resupply equipment shall be of sufficient capacity to permit continuous operations. The hose, wand, and nozzle shall be capable of cleaning the crack faces and the pavement surface on both sides of the crack for a width of at least 13 mm (1/2 inch). A pressure gauge mounted at the pump shall show at all times the pressure in kPa (psi) at which the equipment is operating.

1.2.4 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from cracks and repairing or cleaning the crack faces.

1.2.5 Crack Sealing Equipment

Provide unit applicators, used for heating and installing the hot-poured crack sealant materials, that are mobile and equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the crack to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. Allow the sealant to circulate through the delivery hose and return to the inner kettle when not in use, due to the applicator unit design.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Installation of Sealant

SD-04 Samples

Materials; G;

SD-06 Test Reports

Test Requirements

1.4 QUALITY ASSURANCE

Test the crack sealant and backup material, when required, for conformance with the referenced applicable material specification. The materials will be tested by the Government. Submit samples of the materials 30 calendar days prior to their use on the project. No material will be allowed to be used until it has been approved. The cost of the first test of samples will be borne by the Government. If the samples fail to meet specification requirements, replace the materials represented by the sample and test the new materials at the Contractor's expense. Furnish samples of materials, in sufficient quantity to be tested upon request. Conformance with the test requirements of the laboratory tests specified will not constitute final acceptance of the materials. Submit reports of all tests. Perform testing of the materials in an approved, independent laboratory; submit certified copies of the test reports for approval 30 calendar days prior to the use of the materials at the job site. Samples will be retained by the Government for possible future testing, should the materials appear defective during or after application. Final acceptance will be based on the performance of the in-place materials.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects; unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site to protect materials from weather and to maintain them at the temperatures recommended by the manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 10 degrees C (50 degrees F) and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the crack.

PART 2 PRODUCTS

2.1 SEALANTS

Provide sealants conforming to ASTM D6690, Type II or ASTM D6690, Type I or KS F 2368. Usage of sealing materials for sealing cracks in the various paved areas indicated on the drawings shall be approved by the Contracting officer.

2.2 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorptive material and nonreactive with the crack sealant. The melting point of the backing material shall be at least 2 degrees C (36 degrees F) greater than the maximum pouring temperature of the sealant being used, when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5 percent by weight when tested in accordance with ASTM C509. The backup material shall be 25 percent (plus or minus 5 percent) larger in diameter than the nominal width of the crack.

PART 3 EXECUTION

3.1 PREPARATION OF CRACKS

Immediately before the installation of the crack sealant, thoroughly clean the cracks to remove oxidized pavement, loose aggregate and foreign debris. The preparation shall be as follows:

3.1.1 Cracks

3.1.1.1 Hairline Cracks

Cracks that are less than 6 mm (1/4 inch) wide shall be sealed in accordance with Section 32 12 11. BITUMINOUS SURFACE TREATMENT

3.1.1.2 Small Cracks

Cracks that are 6 to 20 mm (1/4 to 3/4 inch) wide shall be routed to a nominal width 3 mm (1/8 inch) greater than the existing nominal width and to a depth not less than 20 mm (3/4 inch), waterblasted or wire brushed and cleaned using compressed air.

3.1.1.3 Medium Cracks

Cracks that are 20 to 50 mm (3/4 to 2 inches) wide shall be waterblasted or wire brushed and cleaned using compressed air.

3.1.1.4 Large Cracks

Cracks that are greater than 50 mm (2 inches) wide shall be repaired using pothole repair techniques instead of sealing.

3.1.2 Existing Sealant Removal

Cut loose the in-place sealant from both crack faces and to a depth shown on the drawings, using a concrete saw or hand tools as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all old loose sealant remaining in the crack opening by blowing with compressed air.

3.1.3 Routing

Perform routing of the cracks using a rotary router with a bit that is at least 3 mm (1/8 inch) wider than the nominal width of the crack to remove all residual old sealant (resealing), oxidized pavement and any loose aggregate in the crack wall.

3.1.4 Sawing

Perform sawing of the cracks using a power-driving concrete saw as specified in paragraph EQUIPMENT. Stiffen the blade as necessary with suitable dummy (or used) blades or washers. Immediately following the sawing operation, clean the crack opening using a water jet to remove all saw cuttings and debris.

3.1.5 Waterblasting

Waterblast clean the crack faces and the pavement surfaces extending a minimum of 13 mm (1/2 inch) from the crack edges. Use a multiple-pass technique until the surfaces are free of dust, dirt, old sealant residue, or foreign debris that might prevent the sealant material from bonding to the asphalt pavement. After final cleaning and immediately prior to sealing, blow out the cracks with compressed air and leave them completely free of debris and water. Ensure that waterblasting does not damage the pavement.

3.1.6 Backup Material

Use backup material on all cracks that have a depth greater than 19 mm (3/4 inch). Insert the backup material into the lower portion of the crack as shown on the drawings. Ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.1.7 Rate of Progress of Crack Preparation

Limit the stages of crack preparation, which include routing, sandblasting of the crack faces, air pressure cleaning and placing of the backup material, to only that linear footage that can be sealed during the same day.

3.2 PREPARATION OF SEALANT

Do not heat hot-poured sealants in excess of the safe heating temperature recommended by the manufacturer, as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.3 INSTALLATION OF SEALANT

Submit manufacturer's instructions 14 calendar days prior to the use of the material on the project. Installation of the material will not be allowed until the instructions are received.

3.3.1 Time of Application

Seal cracks immediately following final cleaning of the crack walls and following the placement of the backup material (when required). Cracks that cannot be sealed under the conditions specified, or when rain interrupts sealing operations, shall be recleaned and allowed to dry prior to installing the sealant.

3.3.2 Sealing the Crack

Immediately preceding, but not more than 15 m (50 feet) ahead of the crack sealing operations, perform a final cleaning with compressed air. Fill the cracks from the bottom up to 3mm 6 mm (1/8 inch 1/4 inch) below the pavement surface for airfield pavements. Remove excess or spilled sealant from the pavement by approved methods and discard it. Fill the cracks from the bottom up to below the pavement surface for roads, streets and parking lots. Install the sealant in a manner which prevents the formation of voids and entrapped air. Several passes with the applicator wand may be necessary to obtain the specified sealant depth from the pavement surface. Do not use gravity methods or pouring pots to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. Cracks shall be checked frequently to ensure that the newly installed sealant is cured to a tack-free condition within 3 hours.

3.4 CRACK SEALANT INSTALLATION TEST SECTION

Prior to the cleaning and sealing of the cracks for the entire project, construct a test section at least 60 m (200 feet) long using the specified materials and approved equipment, to demonstrate the proposed sealing of all cracks of the project. Following the completion of the test section and before any other crack is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements, remove the materials and reclean and reseal the cracks at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the contract unit price per linear foot for sealing items scheduled. Seal all other cracks in the manner approved for sealing the test section.

3.5 CLEANUP

Upon completion of the project, remove unused materials from the site and leave the pavement in a clean condition.

3.6 QUALITY CONTROL PROVISIONS

3.6.1 Crack Cleaning

Provide quality control provisions during the crack cleaning process to correct improper equipment and cleaning techniques that damage the bituminous pavement in any manner. Cleaned cracks shall be approved prior to installation of the crack sealant.

3.6.2 Crack Seal Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements and proper installation. Evidences of bubbling, improper installing, and failing to cure or set will cause to suspend operations until causes of the deficiencies are determined and corrected.

3.6.3 Crack Sealant

Inspect the crack sealant for proper cure and set rating, bonding to the bituminous pavement, cohesive separation within the sealant, reversion to liquid, and entrapped air and voids. Sealants exhibiting any of these deficiencies, at any time prior to the final acceptance of the project, shall be removed from the crack, wasted, and replaced as specified herein at no additional cost to the Government.

-- End of Section --

SECTION 32 01 19.61

RESEALING OF JOINTS IN RIGID PAVEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C603	(2004; R 2008) Extrusion Rate and Application Life of Elastomeric Sealants
ASTM C639	(2001; R 2011) Rheological (Flow) Properties of Elastomeric Sealants
ASTM C661	(2006; R 2011) Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
ASTM C679	(2003; E 2009; R 2009) Tack-Free Time of Elastomeric Sealants
ASTM C719	(2013) Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
ASTM C792	(2004; R 2008) Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
ASTM C793	(2005; R 2010) Effects of Accelerated Weathering on Elastomeric Joint Sealants
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-1401	(Rev C; Am 1; Notices 1, 2) Sealant, Joint, Non-Jet-Fuel-Resistant, Hot-Applied, for Portland Cement and Asphalt Concrete Pavements
FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Joint sealant

Submit catalog cuts, specifications, material Safety Data Sheets and other information documenting conformance to contract requirements.

SD-04 Samples

Joint filler

Separating tape

Joint backer rod

Joint sealant

Furnish for testing a five gallon sample of each joint seal with associated primer to the Contracting Officer a minimum of 30 calendar days prior to its use on the job. Each container shall be factory sealed and must contain a factory applied label showing the following information:

Name of sealant

Identification of component, or primer

Specification number and type

Manufacturer's name

Manufacturer's lot and batch number

Date of Manufacture (month and year)

Shelf life retest date (month and year)

List of hazardous components

Quantity of material in container (volume)

Storage instructions

Instructions for use

SD-06 Test Reports

Joint sealant

SD-07 Certificates

Equipment list

SD-08 Manufacturer's Instructions

Joint sealant

Instructions shall include, but not be limited to: storage requirements, ambient temperature and humidity ranges, and moisture condition of joints for successful installation; requirements for preparation of joints; safe heating temperature; mixing instructions; installation equipment and procedures; application and disposal requirements; compatibility of sealant with filler material; curing requirements; and restrictions to be adhered to in order to reduce hazards to personnel or to the environment. Submit instructions at least 30 days prior to use.

1.3 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for visible damage, and unload and store with a minimum of handling. Joint materials shall be delivered in original sealed containers and shall be protected from freezing or overheating. Provide jobsite storage facilities capable of maintaining temperature ranges within manufacturers recommendations.

1.4 ENVIRONMENTAL REQUIREMENTS

Work shall not proceed when weather conditions detrimentally affect the quality of cleaning joints or applying joint sealants. Joint preparation and sealing shall proceed only when weather conditions are in accordance with manufacturer's instructions. During installation, surfaces shall be dry and sealant and bond breakers shall be protected from moisture.

1.5 TRAFFIC CONTROL

Do not permit vehicular or heavy equipment traffic on the pavement in the area of the joints being sealed during the protection and curing period of the joint sealant. At the end of the curing period, traffic may be permitted on the pavement when approved.

1.6 EQUIPMENT

Submit an equipment list and description of the equipment to be used and a statement from the supplier of the joint sealant that the proposed equipment is acceptable for installing the specified sealant. Equipment for heating, mixing, and installing joint seals shall be in accordance with the instructions provided by the joint seal manufacturer. Furnish equipment, tools, and accessories necessary to clean existing joints and install liquid joint sealants. Maintain machines, tools, and other equipment in proper working condition.

1.6.1 Joint Cleaning Equipment

1.6.1.1 Routing Tool

To remove old sealant from joints, select rectangular shaped routing tool that is adjustable to varying widths and depths required. The equipment shall be capable of maintaining accurate cutting depth and width control. The joint plow shall be equipped with a spring or hydraulic mechanism to release pressure on the tool prior to spalling the concrete.

1.6.1.2 Concrete Saw

Self-propelled power saw with diamond saw blades designed for sawing, refacing, widening, or deepening existing joints as specified without damaging the sides, bottom, or top edge of joints. Blades may be single or gang type with one or more blades mounted in tandem for fast cutting. Select saw adequately powered and sized to cut specified opening with not more than two passes of the saw through the joint.

1.6.1.3 Waterblasting Equipment

Commercial type capable of removing residual sealer, oil, or other foreign material. Equipment shall include an air compressor, hose and nozzles of proper size, shape, and opening. Attach an adjustable guide that will hold the nozzles aligned with the joint to effectively and efficiently clean without damage to concrete edges. Adjust height, angle of inclination, or size of nozzles to sandblast joint faces and not bottom of joint.

1.6.1.4 Air Compressor

Portable air compressor capable of operating the sandblasting equipment and capable of blowing out sand, water, dust adhering to sidewalls of concrete, and other objectionable materials from the joints. The compressor shall furnish air at a pressure not less than 620 kPa (90 psi) and a minimum rate of 4.0 cubic meters of air per minute (150 cubic feet of air per minute) at the nozzles and free of oil.

1.6.1.5 Vacuum Sweeper

Self-propelled, vacuum pickup sweeper capable of completely removing loose sand, water, joint material, and debris from pavement surface.

1.6.1.6 Hand Tools

When approved, hand tools such as brooms and chisels may be used in small areas for removing old sealant from joints and repairing or cleaning the joint faces.

1.6.2 Joint Sealing Equipment

Joint sealing equipment shall be of a type required by the joint seal manufacturer's installation instructions. Equipment shall be capable of installing sealant to the depths, widths and tolerances indicated. When malfunctions are noted, joint sealing shall not proceed until they are corrected.

1.6.2.1 Two-Component Cold-Applied Liquid Sealants

For two component cold applied machine mixed sealants the equipment shall be capable of delivering each component within an accuracy of 5 percent. Equip reservoirs for each component with mechanical agitation devices. Equip equipment with thermostatically controlled indirect heating of components when required. Equipment shall include screens over each reservoir to eliminate foreign particles or partially polymerized material which may clog lines. Equipment shall be capable of intimately mixing the two components through a range of application rates from 40 to 230 liters per hour (10 to 60 gallons per hour) and through a range of pressures from 345 to 1034 kPa (50 to 150 pounds per square inch). Hand-mixing of cold-applied two component sealant may be done at the option of the Contractor for sealants conforming to FS SS-S-200, Type H.

1.6.2.2 Equipment for Silicone Sealant

Equipment for silicone sealant shall be air powered pump, components, and hoses as recommended by the sealant manufacturer. Hoses and seals shall be lined to prevent moisture penetration and withstand pumping pressures. Equipment shall be free of contamination from previously used or other type sealant.

1.7 SAFETY PROVISIONS

In accordance with the provisions of the contract respecting "Accident Prevention," the Contractor shall take appropriate measures to control worker exposure to toxic substances during the work. Provide personnel protective equipment as required. Material Safety Data Sheets (Department of Labor Form OSHA-20 or comparable form) shall be available on the site.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Joint Sealant

2.1.1.1 Two Component Cold-Applied Sealing Compound

FS SS-S-200, Type H for small areas or M for large areas.

2.1.1.2 Sealant, Joint, Non-Jet Fuel Resistant, Hot Applied

FS SS-S-1401, for portland cement and asphalt concrete pavements.

2.1.1.3 Single Component Cold-Applied Silicone

Silicone sealant shall be self leveling, non-acid curing, and meet the following requirements:

TEST	TEST METHOD	REQUIREMENTS
Weight Loss	ASTM C792 Modified (see note 1 below)	10 percent max.
Flow	ASTM C639 (Type I)	smooth and level
Extrusion Rate	ASTM C603	30 sec. max.
Tack Free Time	ASTM C679	5 hours max.
Hardness (Shore 00) (see note 2 below)	ASTM C661	30 - 80
Tensile Stress at 150 Percent Elongation (see note 2 below)	ASTM D412 (Die C)	207 kPa max. (30 psi max.)
Percent Elongation (see note 2 below)	ASTM D412 (Die C)	700 min.

TEST	TEST METHOD	REQUIREMENTS
Accelerated Weathering	ASTM C793	pass 5,000 hours
Bond and Movement Capability	ASTM C719	pass 10 cycles at ±50 percent movement (no adhesion or cohesion failure)
Flame Resistance	FS SS-S-200	pass

Notes:

1. Percent weight loss of wet (uncured) sample after placing in forced-draft oven maintained at 70 ± 2 degrees C (158 degrees ± 36 degrees F) for two hours.

2. Specimen cured 21 days at 23 ± 2 degrees C (73 ± 36 degrees F)and 50 percent ± 5 percent humidity.

ACCELERATED WEATHERING FACTORY TEST REPORT. For the Accelerated Weathering test, in lieu of testing of actual joint sealant to be used on the project, a report of a factory test, performed within two years of contract award, may be submitted.

2.1.2 Primers

Select concrete primer recommended by the manufacturer of the proposed liquid joint sealant.

2.1.3 Bond Breakers

2.1.3.1 Blocking Media

Compressible, nonshrinkable, nonreactive with joint sealant and nonabsorption type such as plastic backer rod, free of oils or bitumens. Blocking media shall be consistent with the joint seal manufacturer's installation instructions and be at least 25 percent larger in diameter than the width of the cleaned and re-faced joints as shown.

2.1.3.2 Separating Tape

Polyethylene or polyester tape, 0.075 mm (3 mil) minimum thickness, or masking tape, nonreactive, nonabsorptive, adhesive-back tape, width equal to width of cleaned and refaced joints as indicated. Separating tape shall be consistent with the joint seal manufacturer's installation instructions.

PART 3 EXECUTION

3.1 JOINT PREPARATION

Unless otherwise indicated, remove existing material, saw, clean and reseal joints. Do not proceed with final cleaning operations by more than one working day in advance of sealant. Thoroughly clean joints by removing existing joint sealing compound, bond-breakers, dirt, and other foreign material with the equipment specified herein, but not limited thereto. Cleaning procedures which damage joints or previously repaired patches by chipping or spalling will not be permitted. Remove existing sealant to the required depth as indicated. Precise shape and size of existing joints vary, and conditions of joint walls and edges vary and include but are not limited to rounding, square edges, sloping, chips, voids, depressions, and projections.

3.1.1 Removal of Existing Material

Remove from the joint the existing sealants by using the specified routing tool. After cutting free the existing sealant from both joint faces, remove sealant to the depth required to accommodate the bond breaking material and to maintain the specified depth for the new sealant. For expansion joints, remove existing sealant to a depth of not less than the indicated depth. 25 mm (1 inch). When existing preformed expansion-joint material is more than 25 mm (1 inch) below the surface of the pavement, remove existing sealant to the top of the preformed joint filler. For joints other than expansion joints, remove in-place sealant to the depth as indicated. At the completion of routing operations, clean pavement surface with vacuum sweeper and clean the joint opening by blowing with compressed air. Protect previously cleaned joints from being contaminated by subsequent cleaning operations.

3.1.2 Refacing of Joints

Reface concrete joint walls. Re-saw joint grooves to the dimensions indicated. Refacing shall be by power-driven concrete saw specified herein to remove residual sealant and a minimum of concrete. Removal shall provide exposure of newly clean concrete. Remove burrs and irregularities from sides of joint faces. Immediately after sawing each joint, thoroughly clean saw cut and adjacent concrete surface. Flush with water under pressure, simultaneously blowing water out with compressed air until debris is removed from the joint. Protect adjacent previously cleaned joint spaces from receiving water and debris during the cleaning operation.

3.1.2.1 Joint Widening (Except Expansion Joints)

Saw joints having groovesas indicated.

3.1.3 Final Cleaning of Joints

3.1.3.1 Waterblasting

Following removal of existing sealant, and sawing, and immediately before resealing, thoroughly clean newly exposed concrete joint faces and pavement surface extending up to 50 mm (2 inches) from each joint edge by waterblasting until concrete surfaces in the joint space are free of sealants, dust, dirt and other foreign materials which would prevent bonding of new sealants to the concrete. Perform waterblasting with specified nozzles, air compressor, and other appurtenant equipment. Position nozzles to clean the joint faces. Make at least two passes; one for each joint face. Make as many passes as required for proper cleaning. Immediately prior to sealing the joint, blow out the joint spaces with compressed air until completely free of sand, water, and dust. Joints shall be dry before installation of joint sealant. Replace expansion joint filler material damaged in performing the work with new materials of the same type and dimensions as the existing material, or with appropriate blocking media.

3.1.4 Bond Breaker

At the time the joints receive the final cleaning and are dry, install bond breaker material as indicated with a steel wheel or other approved device.

3.1.4.1 Blocking Media (Backer Rod) (Except for Expansion Joints)

Plug or seal off the lower portion of the groove by installing the specified blocking media as indicated.

3.1.4.2 Separating Tape

Insert the specified tape as indicated.

3.1.5 Rate of Progress

The final stages of joint preparation, which include placement of bond breakers, if required, shall be limited to only that length of joint that can be resealed during the same workday.

3.1.6 Disposal of Debris

Sweep from pavement surface to remove excess joint material, dirt, water, sand, and other debris by vacuum sweepers or hand brooms. Remove the debris immediately in accordance with Section 02 41 00 DEMOLITION AND DECONSTRUCTION.

3.2 PREPARATION OF SEALANT

3.2.1 Hot-Poured Type

Heat hot-poured sealing materials in accordance with safe heating temperature ranges recommended by the manufacturer. Withdraw and waste sealant that has been overheated or subjected to heating for over 3 hours or that remain in the applicator at the end of the day's operation. Heat sealant in specified equipment.

3.2.2 Cold-Applied, Two Component Type

Reject materials which contain water, hard caking of separated constituents, nonreversible jell, or other unsatisfactory conditions such as settlement of constituents into a soft mass that cannot be readily and uniformly remixed in the field with simple tools. In conformance with the manufacturer's recommendations, mix individual components in separate shipping containers before transferring components to appropriate reservoirs of application equipment. Thoroughly mix components to ensure homogeneity of components and incorporation of constituents at time of transfer. When necessary, for remixing prior to transfer, warm components to a temperature not exceeding 32 degrees C (90 degrees F) by placing components in heated storage or by other approved methods. In no case shall components be heated by direct flame or in single-walled, non-oil-bath heating kettles. Hand mixing of cold-applied two component sealant may be done at the option of the Contractor for sealants conforming to FS SS-S-200, Type H.

3.3 INSTALLATION OF SEALANT

3.3.1 Test Section

Install a test section of 60 meters (200 feet) at the start of the sealing operation for each type sealant to be used. A representative of the joint seal manufacturer shall be on site full time during the installation of the test section. Test section shall meet contract requirements. The Contracting Officer shall be notified upon completion of the test section.

3.3.2 Time of Application

After approval of the test section, seal joints immediately following final cleaning and placing of bond breakers. Commence sealing joints when walls are dust free and dry, and when weather conditions meet joint seal manufacturer's instructions. If the above conditions cannot be met, or when rains interrupts sealing operations, reclean and permit the joints to dry prior to installing the sealant.

3.3.3 Sealing the Joints

Do not install joint sealant until joints to be sealed have been inspected and approved. Install bond breaker just prior to pouring sealant. Fill the joints with sealant from bottom up until joints are uniformly filled solid from bottom to top using the specified equipment for the type of sealant required. Fill joints to 6 mm (1/4 inch) below top of pavement within tolerances as indicated, and without formation of voids or entrapped air. Except as otherwise permitted, tool the sealant immediately after application to provide firm contact with the joint walls and to form the indicated sealant profile below the pavement surface. Remove excess sealant that has been inadvertently spilled on the pavement surface. When two-component sealants are placed, each day check hourly the proportioning capability of the equipment to determine that the preset volume output for each component is being maintained. The material used for these checks may be returned to the proper component reservoir. In no case shall two component sealants be installed using gravity methods and pouring spouts, except for approved hand mixing methods. When a primer is supplied or recommended by the manufacturer of a two component sealant, apply the primer evenly to the joint faces in accordance with the manufacturer's recommendations. Check sealed joints frequently to assure that newly installed sealant is cured to a tack-free condition within 5 hours. Protect new sealant from rain during curing period.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling Joint Seal

Obtain a one gallon sample of each type of joint seal on the project from material used for each 3,000 meters (10,000 feet) or less of joints sealed. Store samples according to joint seal manufacturer's instructions. Retain samples until final acceptance of the work by the Contracting Officer.

3.4.2 Joints

Inspect and approve joints which have been cleaned and have backer rods or bond breaking tape installed prior to sealing.

3.4.3 Joint Seal Test Section

Inspect joint seal test section with the Contracting Officer. The joint seal manufacturer's representative shall provide written notice of deficiencies and required corrections or adjustments in joint seal installation procedures. Correct deficiencies and obtain approval of test section by the Contracting Officer prior to installing joint seals.

3.4.4 Joint Sealer

Inspect installed joint seals for conformance to contract requirements, joint seal manufacturer's instructions, and the test section. Obtain approval for each joint seal installation.

3.5 ACCEPTANCE

Reject joint sealer that fails to cure properly, or fails to bond to joint walls, or reverts to the uncured state, or fails in cohesion, or shows excessive air voids, blisters, surface defects, swelling, or other deficiencies, or is not properly recessed within indicated tolerances. Remove rejected sealer and reclean and reseal joints in accordance with the specification. Perform removal and reseal work promptly by and at the expense of the Contractor.

-- End of Section --

SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C509	(2006; R 2011) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D5893/D5893M	(2010) Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	(2012) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D7116	(2005) Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavement
ASTM D789	(2007; E 2010) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 525	(1989) Corps of Engineers Test Method for Evaluation of Hot-Applied Joint Sealants for Bubbling Due to Heating

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2368	(2006) Testing method for sealant and filler, hot-applied, for joints and cracks in asphaltic and portland cement concrete pavements

1.2 SYSTEM DESCRIPTION

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started maintained in satisfactory condition at all times.

1.2.1 Joint Cleaning Equipment

1.2.1.1 Tractor-Mounted Routing Tool

Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

1.2.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

1.2.1.3 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The maximum nozzle opening should not exceed 6.4 mm (1/4 inch). The air compressor shall be portable and capable of furnishing not less than 71 L/s (150 cfm) and maintaining a line pressure of not less than 621 kPa (90 psi) at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 25 mm (1 inch) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

1.2.1.4 Water Blasting Equipment

Include with the water blasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 25 mm (1 inch) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in kPa (psi) at which the equipment is operating.

1.2.1.5 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

1.2.2 Sealing Equipment

1.2.2.1 Hot-Poured Sealing Equipment

The unit applicators used for heating and installing ASTM D6690, ASTM D7116, or KS F 2368 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

1.2.2.2 Two-Component, Cold-Applied, Machine Mix Sealing Equipment

Provide equipment used for proportioning, mixing, and installing FS SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of 1 to 1 by volume using pumps with an accuracy of plus or minus 5 percent for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 32.2 degrees C (90 degrees F). Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 37.8 to 189 L (10 to 60 gallons) per hour and through a range of application pressures from 345 kPa to 10.3 MPa (50 to 1500 psi) as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval.

1.2.2.3 Two-Component, Cold-Applied, Hand-Mix Sealing Equipment

Mixing equipment for FS SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer's recommendations. Submit one hard copy & one digital copy (.pdf - text searchable) manufacturer's recommendations, 30 days prior to use on the project, where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

1.2.2.4 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing ASTM D5893/D5893M single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's Recommendations; G
Equipment

SD-06 Test Reports

Certified copies of the test reports; G.

1.4 QUALITY ASSURANCE

1.4.1 Safety

Do not place joint sealant within 8 m (25 feet) of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Thoroughly clean joints in this area and leave them unsealed.

1.4.2 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable material specification. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 30 days prior to the use of the materials at the job site. No material will be allowed to be used until it has been approved.

1.4.3 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 60 m (200 feet) long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the contract unit price per linear foot for sealing items scheduled. Prepare and seal all other joints in the manner approved for sealing the test section.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 10 degrees C (50 degrees F) and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the joint.

PART 2 PRODUCTS

2.1 SEALANTS

Materials for sealing cracks in the various paved areas indicated on the drawings shall be as follows:

Area	Sealing Material
Roadways, vehicle parking lots and on some aircraft taxiways	ASTM D6690 (Type II or III) or ASTM D5893/D5893M and COE CRD-C 525 or KS F 2368
Aircraft parking aprons and some vehicle maintenance areas	ASTM D7116 and COE CRD-C 525
Aircraft warm up areas, the first 150 m (500 feet) of runways and some aircraft parking aprons (large areas)	FS SS-S-200 Type M
Aircraft warm up areas, the first 150 m (500 feet) of runways and some aircraft parking aprons (small areas)	FS SS-S-200 Type H

2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 3 degrees C (5 degrees F) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C509. The backup material shall be 25 plus or minus 5 percent larger in diameter than the nominal width of the crack.

2.4 BOND BREAKING TAPES

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 3 degrees C (5 degrees F) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 3 mm (1/8 inch) wider than the nominal width of the joint and shall not bond to the joint sealant.

PART 3 EXECUTION

3.1 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

3.1.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings, using the tractor-mounted routing equipment, concrete saw, or water blaster as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks. Chipping, spalling, or otherwise damaging the concrete will not be allowed.

3.1.2 Sawing

3.1.2.1 Refacing of Joints

Accomplish refacing or facing of joints using a concrete saw as specified in paragraph EQUIPMENT to remove all residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings or to saw through sawed and filler-type joints to loosen and remove material until the joint is clean and open to the full specified width and depth. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

3.1.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in paragraph EQUIPMENT. The saw blade shall be 152 mm (6 inches) or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade, as necessary, with suitable dummy (or used) blades or washers. Immediately following the sawing operation, thoroughly clean the crack opening using a water jet to remove all saw cuttings and debris.

3.1.3 Sandblasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 13 mm (1/2 inch) from the joint edges shall be sandblasted, water blasted clean. use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water.

3.1.4 Back-Up Material

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.1.5 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

3.1.6 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.2 PREPARATION OF SEALANT

3.2.1 Hot-Poured Sealants

Sealants conforming to ASTM D6690, ASTM D7116, or KS F 2368 shall not be heated in excess of the safe heating temperature recommended by the manufacturer as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.2.2 Type M Sealants

Inspect the FS SS-S-200 Type M sealant components and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection. Prior to transfer of the components from the shipping containers to the appropriate reservoir of the application equipment, thoroughly mix the materials to ensure homogeneity of the components and incorporation of all constituents at the time of transfer. When necessary for remixing prior to transfer to the application equipment reservoirs, warm the components to a temperature not to exceed 32 degrees C (90 degrees F) by placing the components in heated storage or by other approved methods but in no case shall the components be heated by direct flame, or in a single walled kettle, or a kettle without an oil bath.

3.2.3 Type H Sealants

Mix the FS SS-S-200 Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

3.2.4 Single-Component, Cold-Applied Sealants

Inspect the ASTM D5893/D5893M sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection.

3.3 INSTALLATION OF SEALANT

3.3.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open joints, that cannot be sealed under the conditions specified, or when rain interrupts sealing operations shall be recleaned and allowed to dry prior to installing the sealant.

3.3.2 Sealing Joints

Immediately preceding, but not more than 15 m (50 feet) ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 3, mm (1/8, inch) plus or minus 1.5 mm (1/16 inch) below the pavement surface, unless otherwise indicated. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

3.4 INSPECTION

3.4.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

3.4.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.

3.4.3 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein at no additional cost to the Government.

3.5 CLEAN-UP

Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

SECTION 32 01 26.71

GROOVING FOR AIRFIELD PAVEMENTS

PART 1 GENERAL

1.1 SYSTEM DESCRIPTION

1.1.1 GROOVING MACHINE

Provide a grooving machine that is power driven, self-propelled, specifically designed and manufactured for pavement grooving, and has a self contained and integrated continuous slurry vacuum system as the primary method for removing waste slurry. The grooving machine shall be equipped with diamond-saw cutting blades, and capable of making at least 457 mm (18 inches) in width of multiple parallel grooves in one pass of the machine. Thickness of the cutting blades shall be capable of making the required width and depth of grooves in one pass of the machine. The cutting head shall not contain a mixture of new and worn blades or blades of unequal wear or diameter. Match the blade type and configuration with the hardness of the existing airfield pavement. The wheels on the grooving machine shall be of a design that will not scar or spall the pavement. Provide the machine with devices to control depth of groove and alignment within the specified tolerances.

1.1.2 Water Supply

Water for the grooving operation shall be provided by the Government with Contracting Officer's approval. The water source shall be described on the shop drawings so the Contractor can determine what Equipment will be required and the transportation means to the job.

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment
Procedures

1.3 ENVIRONMENTAL REQUIREMENTS

Grooving operations will not be permitted when freezing conditions prevent the immediate removal of debris and/or drainage of water from the grooved area. Discharge and disposal of waste slurry shall be the Contractor's responsibility. Waste slurry discharge pits may be constructed along side the pavement to be grooved, as directed by the Contracting Officer. Provide and maintain temporary storm drainage, pollution control, and erosion control features at each discharge pit in accordance with base environmental regulations. After the waste slurry has been dewatered, the hardened slurry shall be excavated and disposed in accordance with the base waste disposal requirements. All disposal pit areas shall be regraded and restored to original condition.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Existing Pavements

Bumps, depressed areas, bad or faulted joints, and badly cracked and/or spalled areas in the pavement shall not be grooved until such areas are adequately repaired or replaced.

3.1.2 New Pavements

Allow new asphalt concrete pavements to cure for a minimum of 30 days before grooving, to allow the material to become stable enough to prevent closing of the grooves under normal use. Permit new portland cement concrete pavements to cure for a minimum of 28 days before grooving.

3.2 GROOVING

3.2.1 Procedures

Submit grooving sequence and method of placing guide lines to control grooving operation. Cut grooves in the asphalt portland cement areas as indicated on the drawings. Begin the grooving at one side of the usable runway taxiway and continue for the full width of the area. Take all reasonable precautions to prevent damage to or roughening of the pavement between grooves. Spalling along or tearing or raveling of the groove edges shall not be allowed. The grooves shall be 6 mm, plus 2 mm, minus 0 mm (1/4 inch, plus 1/16 inch, minus 0 inch) wide by 6 mm, plus or minus 2 mm (1/4 inch, plus or minus 1/16 inch) deep and 38 mm, plus 0 mm, minus 3 mm (1-1/2 inches, plus 0 inches, minus 1/8 inch) center to center spacing. The groove length shall be shall terminate within 1.5 m (5 feet) of pavement edge and perpendicular to the longitudinal axis of the centerline of the runway taxiway. The transverse alignment of the grooves shall not vary more than 75 mm (3 inches) plus or minus on a 23 m (75 feet) length of grooving. Do not groove within 150 mm plus or minus 75 mm (6 inches plus or minus 3 inches) of the runway centerline. Do not groove within 150 mm (6 inches) of transverse joints or working cracks, through compression seals, in-runway lighting fixtures or similar items, the first 3 m (10 feet) either side of an arresting barrier cable or the first and last 3 m (10 feet) of the runway.

3.2.2 Clean-Up

Submit a list of proposed equipment to be used in performance of construction work, including descriptive data and safety precautions required for the equipment operation. Clean-up shall be continuous. Flush debris produced by the equipment to the edge of the grooved area or pick it up before it dries and hardens. The dust coating remaining shall be flushed to the edge of the area if the resultant accumulation is not detrimental to the vegetation or storm drainage system. Accomplish all flushing operations in a manner to prevent erosion on the shoulders, damage to vegetation, or plugging of storm drainage.

3.2.3 Repair of Damaged Pavement

Repair at the Contractor's expense, any damage, which in the opinion of the Contracting Officer will be detrimental to aircraft operations and/or pavement performance, occurring to the pavement as a result of the grooving operations.

3.3 CONTRACTOR QUALITY CONTROL

3.3.1 Test Section

Groove a test section in an area of the pavement outside of the trafficked area, as approved by the Contracting Officer. Demonstrate the setup and alignment process, the grooving operation, and the waste slurry disposal.

3.3.2 Inspections

At the beginning of each work shift, furnish a full complement of grooving blades with each saw that are capable of cutting grooves of the specified width, depth, and spacing. If during the work, a single grooving blade on a machine becomes incapable of cutting a groove, continue work for the remainder of the work shift. The Contractor is not required to cut the groove omitted because of the failed blade. Should two or more grooving blades on a machine become incapable of cutting grooves, cease operating the machine until it is repaired.

-- End of Section --

SECTION 32 01 29.61

PARTIAL DEPTH PATCHING OF RIGID PAVING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM C1059/C1059M	(1999; R 2008) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C1581/C1581M	(2009a) Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C173/C173M	(2014) Standard Test Method for Air

	Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M	(2014) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C469/C469M	(2010) Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C531	(2000; R 2012) Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings, and Polymer Concretes
ASTM C666/C666M	(2003; R 2008) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C685/C685M	(2011) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C881/C881M	(2013) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C882/C882M	(2013) Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for

	Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2402	(2007) Slump of Concrete
KS F 2403	(2014) Making and Curing Concrete Specimens
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2438	(2002; R 2012) Testing method for static modulus of elasticity and Poission's ratio in compression of cylindrical concrete specimens
KS F 2449	(2002) Method of test for air content of fresh concrete by volumetric method
KS F 2456	(2013) Testing method of resistance of concrete to rapid freezing and thawing
KS F 2501	(2007) Sampling Aggregate
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine
KS F 2526	(2007) Aggregate for Concrete
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 2547	(1997; R 2012) Testing method for potential alkali reactivity of carbonate rocks for concrete aggregates (rock cylinder method)
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 4007	(2002) Sheet Materials for Curing Concrete
KS F 4009	(2011) Ready-Mixed Concrete

KS L 5201	(2013) Portland Cement
KS T 1072	(2012) Jute Bag

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; G
Proprietary Cementitious Products
pigmented liquid membrane-forming compound

SD-04 Samples

Absorbent curing material
Joint filler; G
Joint sealant; G

SD-05 Design Data

Concrete Mix Design; G

SD-06 Test Reports

Laboratory Test Results; G
Aggregates gradation
Cement
Concrete slump
Concrete air content
Concrete strength (cylinder)
mixer calibration and efficiency

SD-07 Certificates

Cement; G
Aggregate; G
Admixtures; G
Absorbent curing material
pigmented liquid membrane-forming compound
Waterproof Sheet; G
Joint filler; G
Joint sealant; G

1.3 QUALITY ASSURANCE

1.3.1 Preconstruction Testing Of Materials

Submit proposed concrete mix design at least 30 days prior to placement.

Provide mix design evaluation and certification by an approved engineering testing laboratory, and indicate the weight of each ingredient of the mixture, aggregate gradation, slump, air content, water-cement ratio, and 7-day and 28-day compressive strength test results. Include a complete list of materials including admixtures and applicable reference specifications. Place no concrete prior to approval of the proposed mix design. No deviation from the approved mix design is permitted without prior approval.

Within 24 hours of physical completion of laboratory testing, submit copies of test results for approval.

1.3.1.1 Cement

Test cement as prescribed in the referenced specification under which it is furnished. Cement may be accepted on the basis of mill tests and the manufacturer's certification of compliance with the specification.

1.3.1.2 Aggregate

Take aggregate gradation samples for laboratory testing in conformance with ASTM D75/D75M or KS F 2501.

1.3.1.3 Proprietary Cementitious Products and Epoxy

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project, not more than 6 months old prior to use in the work.

Manufacturer's certifications may be submitted rather than laboratory test results for proprietary cementitious products. Include in the instructions details for substrate preparation, mixing, placing, finishing, curing and testing of the material. Include a minimum of three case histories documenting the use of the product in a similar freeze-thaw environment and airfield pavement condition. Certify compliance with the appropriate specification referenced herein. Place no materials without prior approval from the Contracting Officer.

1.3.2 Equipment; Approval, Maintenance, and Safety

Provide and use only dependable and well maintained equipment that is appropriate to accomplish the work specified. Allow sufficient time for assembly of equipment requiring such at the work site to permit thorough inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required prior to the start of work.

Submit volumetric mixer calibration and efficiency test results. Results must be current within 6 months of concrete placement.

Provide Material Safety Data Sheets (MSDS) and Personal Protection Equipment (PPE) per 29 CFR 1910.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Cement

Deliver cement in bulk or in suitable bags used for packaging cements and store in a manner to prevent absorption of moisture.

1.4.2 Aggregate

Deliver, handle, and store aggregate in a manner to avoid breakage, segregation, or contamination by foreign materials.

1.4.3 Other Materials

Deliver epoxy-resin, chemical admixtures and proprietary cementitious products to the site in such manner as to avoid damage or loss. Provide storage areas in a windowless and weatherproof, but ventilated, insulated noncombustible building, with provision nearby for conditioning the material to 20 to 30 degrees C (70 to 85 degrees F) for a period of 48 hours prior to use. Keep the ambient temperature in the storage area no higher than 40 degrees C (100 degrees F).

1.5 Project/Site Conditions

Do not place concrete when weather conditions detrimentally affect the quality of the finished product. Do not place concrete when the air temperature is below 5 degrees C (40 degrees F) in the shade. When air temperature is likely to exceed 35 degrees C (90 degrees F), provide concrete having a temperature not exceeding 35 degrees C (90 degrees F) when deposited. Keep the surface of placed concrete damp with a water fog until the approved curing medium is applied.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Coarse Aggregate

2.1.1.1 Composition

Provide coarse aggregate consisting of gravel, crushed gravel, crushed stone, or a combination thereof.

2.1.1.2 Quality

Provide aggregate , as delivered to the mixers, consisting of clean, hard, unweathered, and uncoated particles. Remove dust and other coatings from the coarse aggregate by adequate washing. Meet the requirements of ASTM C33/C33M, Class 4S for deleterious substances or KS F 2526. Abrasion loss, when tested in accordance with ASTM C131 or KS F 2508, must not exceed 40 percent; the maximum allowable percentage for clay lumps and friable particles is 3.0 percent. Provide documentation of aggregate conforming to ASTM C136 or KS F 2502.

2.1.1.3 Particle Shape

Provide spherical or cubical shaped coarse aggregate particles.

2.1.1.4 Gradation

The maximum nominal size of the coarse aggregate is 13 mm (1/2 inch). Provide well graded coarse aggregate, within the limits specified, and tested in accordance with ASTM C136 or KS F 2502, and conforming to the following grading requirements as delivered to the batching hoppers:

Sieve designation U.S. Standard square mesh	Percentage by weight passing individual sieves 4.75 mm to 12.5 mm (No. 4 to 1/2 inch)
19.0 mm (3/4 inch)	100
12.5 mm (1/2 inch)	90-100
9.5 mm (3/8 inch)	40-70
4.75 mm (No. 4)	0-15
2.36 mm (No. 8)	0-5

2.1.1.5 Alkali Silica Reactivity

Evaluate and test coarse aggregate, to be used in all concrete, for alkali-silica reactivity in accordance with ASTM C1260 or KS F 2547. Measured expansion must not exceed 0.08 percent at 28 days when tested. Test data indicating an expansion greater than 0.08 percent will be rejected.

Evaluate coarse aggregate in accordance with Section 32 13 11, paragraph: Alkali-Silica Reactivity, with mitigation of reactive aggregate in accordance with the referenced paragraph.

2.1.2 Fine Aggregate

2.1.2.1 Composition

Provide fine aggregate consisting of either natural sand, manufactured sand, or a combination of natural and manufactured sand, and composed of clean, hard, durable particles; conforming to ASTM C33/C33M, Table 1 for deleterious substances or KS F 2526.

2.1.2.2 Particle Shape and Quality

Ensure particles of the fine aggregate are generally spherical or cubical in shape.

2.1.2.3 Grading

Conform grading of the fine aggregate as delivered to the mixer to the following requirements when tested in accordance with ASTM C136 or KS F 2502.

Sieve designation U.S. Standard square mesh	Percentage by weight, passing
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	80-90
1.18 mm (No. 16)	60-80
0.60 mm (No. 30)	30-60
0.30 mm (No. 50)	12-30
0.15 mm (No. 100)	2-10

In addition, provide fine aggregate, as delivered to the mixer, with a fineness modulus of not less than 2.40 nor more than 2.90, when calculated in accordance with ASTM C136 or KS F 2502.

2.1.2.4 Alkali Silica Reactivity

Evaluate and test fine aggregate to be used in all concrete for alkali-silica reactivity using the procedures described for coarse aggregate.

2.1.3 Admixtures

2.1.3.1 Air-Entraining Admixtures

Provide air-entraining admixtures conforming to ASTM C260/C260M or KS F 2560.

2.1.3.2 Chemical Admixtures

ASTM C494/C494M or KS F 2560. Where not shown or specified, the use of admixtures is subject to written approval of the Contracting Officer.

2.1.4 Cement

Provide portland cement conforming to ASTM C150/C150M, Type I, II or III or KS L 5201 Class I, II or III. Provide low alkali cement if the proposed fine or coarse aggregate are found to have greater than 0.04 percent expansion when tested in accordance with paragraphs: Alkali Silica Reactivity.

2.1.4.1 Portland Cement Mix Design

Design the concrete mixture to produce a minimum compressive strength of 31 MPa (4,500 psi) 35 MPa (5,000 psi) at 28 days of age, determined in conformance with ASTM C39/C39M and ASTM C192/C192M, using standard 150 by 300 mm (6 by 12 inches) cylinder specimens; and providing an air content by volume of 6 percent, plus or minus 1.5 percent, based on measurements made on concrete immediately after discharge from the mixer in conformance with ASTM C231/C231M.

The allowable range of slump is 13 to 50 mm (1/2 to 2 inches) when tested in accordance with ASTM C143/C143M or KS F 2402 except that maximum slump may be increased to 100 mm (4 inches) when the Contractor has included an approved water-reducing, high range, admixture conforming to ASTM C494/C494M in the mix design. To minimize drying shrinkage, the maximum water-cement ratio by weight is 0.45.

2.1.5 Curing Materials

2.1.5.1 Burlap

Provide burlap conforming to AASHTO M 182 or KS T 1072.

2.1.5.2 Pigmented Liquid Membrane-Forming Compound

Provide pigmented liquid membrane-forming compound conforming to COE CRD-C 300 or KS F 2540.

2.1.5.3 Waterproof Sheet Materials

Provide waterproof sheet materials conforming to ASTM C171, Type optional, color white or KS F 4007.

2.1.6 Bonding-Agents

2.1.6.1 Epoxy-Resin

Provide two component epoxy-resin material formulated to meet the requirements of ASTM C881/C881M, Type III, grade and class as approved, for use in bond coat applications and as a component of epoxy-resin concrete or mortar.

Mix epoxy-resin grout components in the proportions recommended by the manufacturer. Condition the components to 20 to 30 degrees C (70 to 85 degrees F) for 48 hours prior to mixing. Mix the two epoxy components with a power-driven, explosion-proof stirring device in a metal or polyethylene container having a hemispherical bottom. Add the curing-agent component gradually to the epoxy-resin component with constant stirring until a uniform mixture is obtained. Stir such that the rate of entrained air is a minimum.

2.1.6.2 Latex

Provide latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II.

2.1.7 Joint Sealant

Provide joint sealant as indicated on the drawings. as specified in Section 32 01 19.61 RESEALING OF JOINTS IN RIGID PAVING.

2.1.8 Joint Filler

Provide joint filler material conforming to ASTM D1751 or ASTM D1752, Type II.

2.1.9 Water

Use only clean, fresh water, free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances. Water approved by Public Health authorities for domestic consumption may be accepted for use without being tested. Test water that is of questionable quality, in the opinion of the Contracting Officer, in accordance with ASTM C1602/C1602M and acceptance criteria of Table 1 of ASTM C94/C94M or KS F 4009.

2.1.10 Proprietary Cementitious Products

A proprietary cementitious product is defined as a rigid material in its hardened state with an elastic modulus greater than 6,900 MPa (1,000,000 psi). Maximum size of aggregate used to extend the product is 19 mm (3/4 inch). Test the product in accordance with the following test series. Replicate each test on three specimens. Report all three results for each test and use the average value for comparison with the specification requirements. Report the curing conditions for each test type.

2.1.10.1 Compressive Strength

Cast 75 by 150 mm (3 by 6 inches) cylinder specimens in accordance with ASTM C192/C192M and test in accordance with ASTM C39/C39M, using bonded or unbonded caps, after 3 hours and 1 day curing period. A minimum compressive strength of 20.7 MPa (3,500 psi) is required at 3 hours and 1 day of age.

2.1.10.2 Bond Strength

Cast 75 by 150 mm (3 by 6 inches) cylinder specimens and test in accordance with ASTM C882/C882M. Cast the candidate material against a 30-degree wedge specimen consisting of the candidate material itself or an ordinary portland cement mixture. Test specimens, using bonded caps, after 1 day curing period. For a bond consisting of the candidate material bonded to OPC mortar, a minimum bond strength of 3,400 kPa (500 psi) is required at 1 day of age. For a bond consisting of the candidate material bonded to itself, a minimum bond strength of 6,900 kPa (1,000 psi) is required at 1 day of age.

2.1.10.3 Modulus of Elasticity

Cast 150 by 300 mm (6 by 12 inches) cylinder specimens in accordance with ASTM C192/C192M and test in accordance with ASTM C469/C469M or KS F 2438, using bonded caps, after 3 day curing period. A maximum chord modulus of elasticity of 27,600 MPa (4,000,000 psi) is required at 3 days of age.

2.1.10.4 Coefficient of Thermal Expansion

Cast 25 by 25 by 250 mm (1 by 1 by 10-inches) prismatic bar specimens and test in accordance with ASTM C531, after 3 days curing period. A maximum coefficient of 11.6 by 10^{-6} mm per degree C (7 by 10^{-6} inch per degree F) is required at 3 days of age.

2.1.10.5 Shrinkage Potential

Cast 330 mm I.D. by 406 mm O.D. by 150 mm (13 inches I.D. by 16 inches O.D. by 6 inches) tall restrained toroidal specimens and test in accordance with ASTM C1581/C1581M. Start measuring strain after completion of casting. A maximum of 40 microstrain is required at 14 days of age. No cracking is permitted at 28 days of age.

2.1.10.6 Freeze-Thaw Resistance

Cast prismatic specimens in accordance with ASTM C192/C192M and test in accordance with ASTM C666/C666M, Procedure A or KS F 2456. Begin freeze-thaw testing after specimens have been immersed in saturated lime-water for 3 days. Report the Durability Factor (DF) and the number of cycles to failure.

2.2 Neat Cement Grout

2.2.1 Sand-Cement Grout Bonding Course

Provide grout bonding course consisting of equal parts of Type I or II, or III portland cement and sand by dry weight, thoroughly mixed with water to yield a thick, creamy mixture; with a water-cement ratio no greater than 0.62 by weight. Sand must meet the requirements of the fine aggregate specified herein, except 100 percent must pass through a 2.36 mm (No. 8) sieve.

2.2.2 Sand-Cement Mortar for Filling Small Popouts

Provide mortar consisting of one part Type I or II, or III portland cement and two parts sand by dry weight, thoroughly mixed with water to yield a thick, suitable mix; with a water-cement ratio no greater than 0.45 by weight. The sand must meet the requirements of the fine aggregate specified herein.

2.2.3 Dowels, Tie Bars, and Reinforcement

Provide dowels, tie bars, and reinforcement as indicated on the drawings.

PART 3 EXECUTION

3.1 PREPARATION OF EXISTING PAVEMENT

3.1.1 Preparation of Existing Surfaces

In the area to be patched, except popouts, remove existing concrete to a minimum depth of 50 mm (2 inches) below the pavement surface adjacent to spalls and to such additional depth where necessary to expose a surface of sound, unweathered concrete that is uncontaminated by sealants, oils, greases, or deicing salts or solutions. Make a vertical saw cut at least 50 mm (2 inches) deep and 50 mm (2 inches) outside of the area needing repair. Accomplish concrete removal in spalled areas with light, hand-held, high-frequency chipping hammers weighing not more than 14 kg (30 pounds) or other approved hand tools. Do not use jack hammers weighing more than 14 kg (30 pounds) and do not use pavement breaker devices mounted on or pulled by mobile equipment.

Clean the cavity surface by waterblasting, blowing with compressed air, sweeping, and vacuums. Use waterblasting to remove all traces of sealer, oils, grease, rust, and other contaminants.

3.1.1.1 Joint Widening (Except Expansion Joints)

Saw joints having grooves as indicated.

3.1.2 Dowels, Tie Bars, and Reinforcement

Cut and remove to minimum dimensions indicated existing dowels and tie bars exposed in joints adjacent to the spall cavity. Perform cutting by saws, torch, or other approved means; do not allow torch or other cutting methods to damage concrete to remain. Clean to bare metal by waterblasting any existing reinforcement or dowels remaining exposed in the repair area. After waterblasting is completed, dry the entire area. Remove any reinforcement that cannot be properly re-embedded in the new repair concrete. Cut and remove at the joint not less than 13 mm (1/2 inch) of existing exposed reinforcement that is continuous through the repair area and is embedded in the adjacent slab.

3.1.3 Preparation of Joints Adjacent to Spalls

Remove existing joint sealing and joint filler materials. Saw as indicated and install insert, cut to appropriate dimensions, to prevent contact between new patch material and existing concrete at existing joints. At the option of the Contractor, a bead of approved caulking material may be installed to preclude new patching material from getting around insert. Clean up any caulking material accidentally deposited on the prepared spall surface.

3.1.4 Disposal of Debris

Sweep from pavement surface to remove excess joint material, dirt, water, sand, and other debris by vacuum sweepers or hand brooms. Remove the debris immediately in accordance with Section 02 41 00 DEMOLITION.

3.1.5 Bonding Coat

Prior to placing concrete, wash the previously prepared surfaces with a high pressure water jet followed by an air jet to remove free water.

3.1.5.1 Neat Cement Grout

Coat the clean and dry surface, including sawed faces, with an approximate 2 mm (1/16 inch) thick coat of neat cement grout. Place the grout just prior to concrete placement and scrub with stiff bristle brushes to fill all voids and crevices in the spall cavity surface. Apply additional brush coats as needed to obtain the required thickness. The concrete patch material must be placed before the grout dries or sets. Remove dried or hardened grout by sandblasting and re-coat the cavity with fresh grout before placing concrete patch material.

3.1.5.2 Epoxy-Resin

Limit epoxy-resin bonding coat to use on patches with a surface area of less than 600 mm (2 feet) square. Coat the clean and dry surface, including sawed faces, with a 0.02 to 0.04 mm (20 to 40 mil) thick film of the epoxy-resin grout. Place the epoxy-resin grout in one application, just prior to concrete placement, with the use of mechanical combination, mixing and spraying equipment, or two coat application with stiff brushes. Scrub the first brush coat into the concrete surface, followed by an additional brush coat to obtain the required thickness. When the brush method is used, the initial coat may be allowed to dry; however, apply the final coat just prior to placement of the concrete.

3.1.5.3 Proprietary Cementitious Products

Apply in accordance with the manufacturer's written instructions.

Test as prescribed in the referenced specification under which it is furnished. Cement may be accepted on the basis of mill tests and the manufacturer's certification of compliance with the specification, provided the cement is the product of a mill with a record for the production of high-quality cement for the past 3 years.

3.1.6 Popout Repair

Popouts, as used herein, are pavement surface defects caused by deterioration of unsatisfactory coarse aggregate, decaying of organic material such as wood or roots, mechanical accidents, or other reasons. Most popouts are indicated on the drawings by average diameter but the actual surface configuration will vary from circular to polygonal. Repair popouts as indicated using sand-cement mortar for small popouts (less than 50 mm (2 inches) in width or depth) and portland cement concrete for large popouts. Clean popout cavities of all dirt and contaminants prior to filling. As indicated on drawings, prepare popout areas by chipping overcoring surface defects in the concrete to eliminate feather edging of the mortar or concrete repair material. After preparing large popout cavities, coat with sand-cement grout bonding course immediately prior to filling with concrete.

3.1.7 Patch Material Selection

Fill the prepared cavity with: Portland cement concrete or latex modified concrete for cavities more than 9,400 cc (600 cubic inches) in volume after removal operations; portland cement mortar for cavities between 850 and 9,400 cc (50 and 600 cubic inches); and epoxy resin mortar or latex modified mortar for those cavities less than 850 cc (50 cubic inches) in size. Proprietary cementitious patching materials may be used, subject to approval by the Contracting Officer.

3.2 BATCHING, MIXING AND PROPORTIONING

Provide facilities for the accurate measurement and control of each of the materials entering the concrete, mortar, or grout. Provide free access for the Contracting Officer to the batching and mixing plant at all times. Provide mixing equipment capable of combining the aggregate, cement, admixture, and water into a uniform mixture and discharging this mixture without segregation.

The use of volumetric batching and continuous mixing is acceptable, provided all operations are in accordance with ASTM C685/C685M.

3.2.1 Equipment

Assemble dependable and operable equipment, allowing time for thorough inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required prior to final approval and the commencement of work. Maintain the equipment in good working condition.

3.2.2 Conveying

Convey concrete from mixer to repair area as rapidly as practicable by methods which prevent segregation or loss of ingredients.

3.2.3 Facilities for Sampling

Provide facilities for readily obtaining representative samples of aggregate and concrete for test purposes. Furnish necessary platforms, tools, and equipment for obtaining samples.

3.2.4 Mix Proportions

Use proportions of materials entering into the concrete mixture in accordance with the approved mix design. Revise the mix design whenever necessary to maintain the workability, strength, and standard of quality required, and to meet the varying conditions encountered during the construction; however, no changes shall be made without prior approval.

3.2.5 Measurement

Provide equipment necessary to measure and control the amount of each material in each batch of concrete. Weigh bulk cement. Cement in unopened bags as packed by the manufacturer may be used without weighing. One bag of portland cement is considered as weighing 42.64 kg (94 pounds). Measure mixing water and air-entraining admixtures by volume or by weight. Consider one liter (one gallon) of water as weighing 1 kg (8.33 pounds).

3.2.6 Workability

Maintain the slump of the concrete at the lowest practicable value, not exceeding the specified value.

3.3 PLACING

3.3.1 Portland Cement Concrete

Place concrete within 90 minutes after the introduction of the mixing water to the cement and aggregate or the introduction of the cement to the aggregate, and before the concrete has obtained its initial set, and before the sand-cement grout bonding course has dried or obtained its initial set. The temperature of the concrete, as deposited in the repair area, must be not less than 10 degrees C (50 degrees F) nor more than 32 degrees C (90 degrees F). Deposit concrete as to require a minimum of re-handling and in such a manner so as to least disturb the sand-cement grout. Place concrete as indicated to maintain existing joints and working cracks; do not allow new repair material to infiltrate or span existing joints and cracks indicated to remain. Place concrete continuously in each spall area. Do not allow workmen to walk on the bonding course surface or in the concrete during placing and finishing operations.

Consolidate the concrete by small spud vibrators not greater than 25 mm (one inch) in diameter, except that repair areas less than 100 mm (4 inches) deep or 0.093 square meter (one square feet) in area may be consolidated by hand tamping or other approved means. To avoid pulling material away from patch edge and to maximize bond strength, work the finishing screed from the center of the patch out to the patch boundary. Fill all saw kerfs extending beyond the repair area with grout. Start finishing operations immediately after placement of the concrete. Match finished surface grade of patched areas to the existing surface grade of the adjacent undisturbed pavement. Keep screeding, floating, or toweling of patch material onto adjacent pavements to a minimum; remove loose or poorly bonded patch material from adjacent surfaces. Before the concrete becomes non-plastic, finish the surface with a broom or burlap drag to approximately match the surface finish of existing adjacent concrete pavement.

3.3.2 Epoxy-Resin Concrete and Mortar

Limit epoxy-resin bonding coat to use on patches with a surface area of less than 600 mm (2 feet) square. Place the epoxy resin materials in layers not over 50 mm (2 inches) thick. Make the time interval between placement of additional layers such that the temperature of the epoxy resin material does not exceed 60 degrees C (140 degrees F) at any time during hardening. Use mechanical vibrators and hand tampers to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens. Use an insert or other bond-breaking medium where the spalled area abuts a joint, to prevent bond at the joint face. Saw a reservoir for the joint sealant to the dimensions required for other joints. Thoroughly clean and seal the reservoir with the sealer specified for the joints.

3.3.3 Proprietary Cementitious Products

Perform placing, consolidating, finishing, and curing operations in accordance with the manufacturer's written instructions.

3.3.4 Joints

Construct new joints as detailed on the drawings and align with existing joints. After curing of the concrete, seal new joints as indicated and specified.

3.4 FIELD QUALITY CONTROL

3.4.1 General Requirements

Furnish concrete samples, taken in the field and tested to determine the slump, air content, and strength of the concrete. Make test cylinders for determining conformance with the strength requirements of these specifications and, when required, for determining the time at which pavements may be placed in service. Determine air content in conformance with ASTM C231/C231M or KS F 2421. Mold and cure test cylinders in conformance with ASTM C31/C31M or KS F 2403 and as specified below. Furnish all materials, labor, and facilities required for molding, curing, and protecting test cylinders at the site and under the supervision of the Contracting Officer. Include furnishing and operating water tanks in curing facilities for test beams, equipped with temperature-control devices that will automatically maintain the temperature of the water at 23 degrees C (73 degrees F) plus or minus 3 degrees C (37 degrees F). Also furnish and maintain at the site, boxes or other facilities suitable for storing the specimens while in the mold at a temperature of 23 degrees C (73 degrees F) plus or minus 6 degrees C (43 degrees F). Tests of the fresh concrete and of the hardened concrete cylinders are to be made by and at the expense of the Contractor. Test Proprietary Cementitious Products in accordance with the manufacturer's written instructions.

3.4.2 Specimens for Strength Tests

Sample concrete in the field and test to determine the slump, air content, and strength of the concrete. Make cylinders for each shift of placed concrete. Mold each group of test cylinders from the same batch of concrete, consisting of a sufficient number of specimens to provide two compressive-strength tests at each test age. Make one group of specimens during the first half of each shift, and the other during the last portion of the shift. However, at the start of paving operations and each time the aggregate source, aggregate characteristics, or mix design is changed, make one additional set of test cylinders.

Determine the air content and slump in conformance with ASTM C173/C173M or KS F 2449 and ASTM C143/C143M or KS F 2402, respectively. Mold and cure test cylinders in conformance with ASTM C31/C31M or KS F 2403. Furnish and maintain at the site, boxes or other facilities suitable for storing the specimens while in the mold at a temperature of 23 degrees C (73 degrees F) plus or minus 5.5 degrees C (42 degrees F). Test cylinders in accordance with ASTM C39/C39M.

3.4.2.1 Test Results

Remove concrete not meeting strength, consistency, and air content requirements and provide new acceptable concrete. The removal and replacement method or methods are subject to approval of the Contracting Officer.

3.4.2.2 Acceptance

Reject any spall repair material that cracks, or delaminates, or loses bond partly or completely, or causes spalling of adjacent portland cement concrete, or is not separated properly from adjacent slabs at joints, or fails to cure uniformly and completely, or is otherwise defective. Remove all unacceptable repairs, including new damaged areas adjacent to new spall patches, and provide new repairs meeting the specifications.

3.5 FINISHING

Start finishing operations immediately after placement of the concrete. Finished surfaces of patched areas are to approximate surface texture of the adjacent undisturbed pavements.

3.6 CURING

Cure the concrete by protection against loss of moisture and rapid temperature changes for a period of not less than 7 days from the beginning of the curing operation for type I or II cement and 3 days for type III cement. Protect unhardened concrete from rain and flowing water. Provide all equipment needed for adequate curing and protection of the concrete on hand and ready to install before actual concrete placement begins. Cure proprietary cementitious products in accordance with manufacturer's recommendations. Failure to comply with curing requirements will be cause for immediate suspension of concreting operations.

3.6.1 Moist Curing

Moist-cure all portland cement concrete patches for the first 24-hours after finishing. Immediately after the finishing operations are complete and the concrete is set sufficiently to prevent marring the surface, cover the entire surface of the newly laid concrete with approved wetted burlap, and keep wet for a period of not less than 24 hours. Keep the surface of the newly laid concrete moist until the burlap coverings are in place. Ensure that moist curing is continuous 24 hours per day and that the entire surface is wet, by having an approved work system. Continue curing the concrete for the duration of the required curing period by this method or one of the methods specified below.

3.6.2 Waterproof-Paper Blankets or Impermeable Sheets

Immediately after removing the covering used for initial curing, moisten the exposed concrete surfaces with a fine spray of water and cover with waterproof-paper blankets, polyethylene-coated-burlap blankets, or impermeable sheets. Saturate polyethylene-coated burlap with water before placing. Place sheets with the light-colored side up. Overlap sheets not less than 300 mm (12 inches) with edges taped or secured to form a completely closed joint. Weight down coverings to prevent displacement or billowing from winds. Immediately repair tears or holes appearing during the curing by patching.

3.6.3 Membrane-Forming Curing Compound

Apply membrane -forming curing compound immediately to exposed concrete surfaces after removing burlap coverings. Apply the curing compound with an overlapping coverage that will give a two-coat application at a coverage of not more than 20 square meters per Liter (200 square feet per gallon) for both coats. When application is made by hand-operated sprayers, apply the second coat in a direction approximately at right angles to the first coat.

Cure concrete properly at joints, but do not allow absorbent curing compound to enter joints that are to be sealed with joint-sealing compounds. Provide a uniform, continuous, cohesive compound film that will not check, crack, or peel, and that will be free from pinholes and other imperfections. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied at the coverage specified above and at no additional cost to the Government. Respray areas covered with absorbent curing material that are damaged by pedestrian and vehicular traffic or by subsequent construction operations within the specified curing period at no additional cost to the Government.

3.7 FINISH TOLERANCE

Provide finished surfaces of patched areas meeting the grade of the adjoining pavements without deviations more than 3 mm (1/8 inch) from a true plan surface within the patched area.

3.8 PAVEMENT PROTECTION

Protect the patched areas against damage prior to final acceptance of the work by the Government. Exclude traffic from the patched areas by erecting and maintaining barricades and signs until the completion of the curing period of the concrete.

3.9 JOINTS

Provide joints conforming in detail and in alignment with the existing joints. After curing of the concrete, prepare and seal the joints in accordance with Section 32 01 19.61 RESEALING OF JOINTS IN RIGID PAVEMENTS.

-- End of Section --

SECTION 32 05 33

LANDSCAPE ESTABLISHMENT
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D2103	(2010) Standard Specification for Polyethylene Film and Sheeting
ASTM D6155	(2006) Nontraditional Coarse Aggregate for Bituminous Paving Mixtures

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA Z133.1	(2006) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

1.2 DEFINITIONS

1.2.1 Pesticide

Any substance or mixture of substances, including biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the U.S. Environmental Protection Agency (EPA). Also, any substance used as a plant regulator, defoliant, disinfectant, or biocide. Examples of pesticides include fumigants, herbicides, insecticides, fungicides, nematicides, molluscicides and rodenticides.

1.2.2 Stand of Turf

95 percent ground cover of the established species.

1.2.3 Planter Beds

A planter bed is defined as an area containing one or a combination of the following plant types: shrubs, vines, wildflowers, annuals, perennials, ground cover, and a mulch topdressing excluding turf. Trees may also be found in planter beds.

1.3 RELATED REQUIREMENTS

Section 32 84 24 IRRIGATION SPRINKLER SYSTEM applies to this section for installation of irrigation equipment requirements, with additions and modifications herein.

Sections 32 92 19 SEEDING and 32 92 23 SODDING apply to this section for installation of seed and sod requirements, with additions and modifications herein.

Section 32 93 00 EXTERIOR PLANTS applies to this section for installation of trees, shrubs, ground cover, vines, and wildflower, with additions and modifications herein.

Section 32 96 00 TRANSPLANTING EXTERIOR PLANTS applies to this section for transplanting of trees, shrubs, ground cover, vines, and wildflower, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Integrated Pest Management Plan; G

SD-03 Product Data

Fertilizer

Mulches Topdressing

Submit documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.

Organic Mulch Materials

Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project.

SD-07 Certificates

Maintenance inspection report

Plant quantities; G

SD-11 Closeout Submittals

Tree, staking and guying removal

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Delivery

Deliver fertilizer, gypsum, or iron to the site in original containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum may be furnished in bulk with a certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Fertilizer, Lime, Iron, Mulch Storage

Material shall be stored in designated areas. Lime and fertilizer shall be stored in cool, dry locations away from contaminants.

1.5.2.2 Antidessicants Storage

Do not store with fertilizers or other landscape maintenance materials.

1.5.3 Handling

Do not drop or dump materials from vehicles.

PART 2 PRODUCTS

2.1 POST-PLANT FERTILIZER

2.1.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

percent available nitrogen as indicated in contract drawings
percent available phosphorus as indicated in contract drawings
percent available potassium as indicated in contract drawings
percent sulfur as indicated in contract drawings
percent iron as indicated in contract drawings

2.2 WATER

Source of water shall be approved by the Contracting Officer, and be of suitable quality for irrigation.

2.3 MULCHES TOPDRESSING

Free from noxious weeds, mold, or other deleterious materials.

2.3.1 Inert Mulch Materials

Recycled porcelain, concrete, stone, or other recycled material complying with ASTM D6155 riverbank stone, crushed pit-run rock, granite chips marble chips, ,crushed bricks, volcanic rock size as indicated in contract drawings. Provide materials from site and construction waste to the greatest extent possible. Mulch shall contain a minimum of 5 percent post-consumer recycled content, or a minimum of 20 percent post-industrial recycled content. Mulch may contain post-consumer or post-industrial recycled content.

2.3.2 Organic Mulch Materials

Wood cellulose fiber, wood chips, ground or shredded bark, shredded hardwood, bark peelings, pine straw mulch, or pine needles recycled from site when available. Biobased content shall be a minimum of 100 percent. Wood cellulose fiber shall be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch shall contain a minimum of 100 percent post-consumer recycled content. Wood-based hydraulic mulch shall contain a minimum of 100 percent recycled material.

2.3.3 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 65 by 65 mm (2-1/2 by 2-1/2 inch) screen. It shall be cleaned of all sticks a minimum 25 mm (1 inch) in diameter and plastic materials a minimum 75 mm (3 inch) length. The material shall be treated to retard the growth of mold and fungi.

2.4 PESTICIDES

Use black sheet polyethylene conforming to ASTM D2103, minimum thickness 4 mm (5/32 inch). Submit an Integrated Pest Management Plan, including weed and pest management strategies proposed alternatives to herbicides and pesticides. Use biological pest controls as approved in the Plan.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide landscape construction maintenance to include irrigation equipment cleaning and adjustments, mowing, edging, overseeding, aeration, fertilizing, watering, weeding, pruning, stake and guy adjusting, and for all newly installedor renovated landscape areas and existing plant material, unless indicated otherwise, and at all areas inside or outside the limits of the construction that are disturbed by the Contractor's operations.

3.1.1 Policing

The Contractor shall police all landscaped areas. Policing includes removal of leaves, branches and limbs regardless of length or diameter, dead vegetation, paper, trash, cigarette butts, garbage, rocks or other debris. Policing shall extend to both sides of fencing or walls. Collected debris shall be promptly removed and disposed of at an approved disposal site.

3.1.2 Drainage System Maintenance

The Contractor shall remove all obstructions from surface and subsurface drain lines to allow water to flow unrestricted in swales, gutters, catch basins, storm drain curb inlets, and yard drains. Remove grates and clear debris in catch basins. Open drainage channels are to be maintained free of all debris and vegetation at all times. Edges of these channels shall be clear of any encroachment by vegetation.

3.2 IRRIGATION ESTABLISHMENT PERIOD

The irrigation establishment period will commence on the date that inspection by the Contracting Officer shows that the new or repaired irrigation equipment furnished under this contract has been satisfactorily installed and is functional and shall continue for a period of 365 days.

3.2.1 Maintenance During the Irrigation Establishment Period

Begin maintenance immediately after irrigation equipment has been installed and is functional. Inspect irrigation equipment at least once a week during the installation and establishment period and perform needed maintenance promptly. Automatic controllers not equipped with rain shut-off sensors shall be turned off during periods of rain that exceed twelve hours of continuous rainfall in one day or during rain storms of one day or more. Once the rain has subsided timers shall be reactivated. Irrigation controllers shall be inspected and reprogrammed after power outages. Contractor shall be responsible for winterization and startup. Sprinkler heads shall direct water away from buildings and hard surfaced areas.

3.2.2 Water Restrictions

The Contractor shall abide by state, local or other water conservation regulations in force during the establishment period. Automatic controller shall be adjusted to comply with the water conservation regulations schedule.

3.2.3 Fire Hydrants

To use a fire hydrant for irrigation, the Contractor shall obtain prior clearance from the Contracting Officer and provide the tools and connections approved for use on fire hydrants. If a fire hydrant is used, Contractor shall provide a reduced pressure backflow preventer for each connection between hose and fire hydrant. Backflow preventer used shall be tested once per month by a certified backflow preventer tester.

3.2.4 Final Acceptance

Upon completion of the irrigation establishment period and final acceptance of groundcover and exterior plants, irrigation equipment shall be removed. Operation and coverage test is acceptable if system operates through at least one complete cycle for areas to be irrigated and all leaks or repairs have been completed.

3.2.5 Controller Charts

Provide one chart for each controller supplied. Indicate in chart area controlled by the automatic controller. The chart is a reduction of the actual plans that will fit the maximum dimensions inside the controller housing. Use a black line print for the chart and a different pastel or transparent color to indicate each station zone of coverage. After chart is completed and approved for final acceptance, seal chart between two 0.5 mm (20 mil) pieces of clear plastic.

3.3 GROUNDCOVER ESTABLISHMENT PERIOD

Groundcover establishment period will commence on the date that inspection by the Contracting Officer shows that the new renovated turf furnished under this contract has been satisfactorily installed to a 95 percent stand of coverage. The establishment period shall continue for a period of 365 days.

3.3.1 Frequency of Maintenance

Begin maintenance immediately after turf has been installed fully renovated. Inspect areas once a week during the installation and establishment period and perform needed maintenance promptly.

3.3.2 Promotion of Growth

Groundcover shall be maintained in a manner that promotes proper health, growth, natural color. Turf shall have a neat uniform manicured appearance, free of bare areas, ruts, holes, weeds, pests, dead vegetation, debris, and unwanted vegetation that present an unsightly appearance. Mow, remove excess clippings, eradicate weeds, water, fertilize, overseed, aerate, top dress and perform other operations necessary to promote growth, as approved by Contracting Officer and consistent with approved Integrated Pest Management Plan. Remove noxious weeds common to the area from planting areas by mechanical means.

3.3.3 Mowing

3.3.3.1 Turf

Turf shall be mowed at a uniform finished height. Mow turfed areas to a minimum average height of 76 mm (3 inches) when average height of grass becomes 76 mm (3 inches) for spring/summer maintenance and to a minimum average height of 76 mm (3 inches) when the average height of grass reaches 76 mm (3 inches) for fall winter maintenance. The height of turf is measured from the soil. Mowing of turf shall be performed in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Prior to mowing, all rubbish, debris, trash, leaves, rocks, paper, and limbs or branches on a turf area shall be picked up and disposed. Adjacent paved areas shall be swept/vacuumed clean.

3.3.3.2 Native Grasses

Mow above height of native grass seedlings (approximately 89 to 102 mm (3.5 to 4 inches)). Mow during spring or early summer. Do not mow after early summer during the second growing season.

3.3.3.3 Wildflowers

Mow three times per season above height of the wildflowers (approximately 305 to 381 mm (12 to 15 inches)).

3.3.4 Turf Edging and Trimming

Perimeter of planter bed edges, sidewalks, driveways, curbs, and other paved surfaces shall be edged. Uniformly edge these areas to prevent encroachment of vegetation onto paved surfaces and to provide a clear cut division line between planter beds, turf, and ground cover. Edging is to be accomplished in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Edging shall be performed on the same day that turf is mowed. Use of string line trimmers is permitted in "soft" areas such as an edge between turf grass and a planter bed. Care shall be exercised to avoid damage to any plant materials, structures, and other landscape features.

Trimming around trees, fences, poles, walls, irrigation valve boxes and other similar objects is to be accomplished to match the height and appearance of surrounding mowed turf growth. Trimming shall be performed on the same day the turf is mowed. Care shall be exercised to avoid "Girdling" trees located in turf areas. The use of protective tree collars on trees in turf areas may be utilized as a temporary means to avoid injury to tree trunks. At the end of the plant establishment period Contractor will be responsible for removing all protective tree collars.

3.3.5 Post-Fertilizer Application

Apply turf fertilizer in a manner that promotes health, growth, vigor, color and appearance of cultivated turf areas. The method of application, fertilizer type and frequencies shall be determined by the laboratory soil analysis results the requirements of the particular turf species. Organic fertilizer shall be used. In the event that organic fertilizer is not producing the desired effect, the Contractor shall contract the Contracting Officer for approval prior to the use of a synthetic type of fertilizer. Fertilizer shall be applied by approved methods in accordance with the manufacturer's recommendations.

3.3.6 Turf Watering

The Contractor shall perform irrigation in a manner that promotes the health, growth, color and appearance of cultivated vegetation and that complies with all Federal, State, and local water agencies and authorities directives. The Contractor shall be responsible to prevent over watering, water run-off, erosion, and ponding due to excessive quantities or rate of application. The Contractor shall abide by state, local or other water conservation regulations or restrictions in force during the establishment period. Irrigation controllers shall be adjusted to comply with the water conservation regulations schedule.

3.3.7 Turf Aeration

Upon completion of weed eradication operations and Contracting Officer's approval to proceed, aerate turf areas by approved device. Core, by pulling soil plugs, to a minimum depth of 300 mm (12 inches). Leave all soil plugs that are produced in the turf area. After aeration operations are complete, top dress entire area to a depth of 12.70 mm (1/4 inch) depth with a mixture of sand, humus, gypsum, and lime in proportions as indicated on the drawings.

Blend all parts of topdressing mixture to a uniform consistency throughout.
Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean all soil plugs off of other paving when work is complete. This work shall commence 10 days prior final acceptance of the maintenance establishment period.

3.3.8 Turf Clearance Area

Trees located in turf areas shall be maintained with a growth free clearance of 450 mm (18 inches) from the tree trunk base. The use of mechanical weed whips to accomplish the turf growth free bed area is prohibited.

3.3.9 Replanting

Replant in accordance with Section 32 92 19 SEEDING and Section 32 92 23 SODDING, and within specified planting dates areas which do not have a satisfactory stand of turf.

3.3.10 Final Inspection and Acceptance

Final inspection will be make upon written request from the Contractor at least 10 days prior to the last day of the turf establishment period. Final turf acceptance will be based upon a satisfactory stand of turf.

3.4 EXTERIOR PLANT ESTABLISHMENT PERIOD

The exterior plant establishment period will commence on the date that inspection by the Contracting Officer shows that the new plantsortransplanted plants furnished under this contract has been satisfactorily installed and shall continue for a period of 365 days.

3.4.1 Frequency of Maintenance

Begin maintenance immediately after plants have been installed. Inspect exterior plants at least once a week during the installation and establishment period and perform needed maintenance promptly.

3.4.2 Promotion of Plant Growth and Vigor

Water, prune, fertilize, mulch, adjust stakes, guys and turnbuckles, eradicate weeds and perform other operations necessary to promote plant growth, and vigor.

3.4.3 Planter Bed Maintenance

Planter beds shall be weeded, fertilized, irrigated, kept pest free, turf free, pruned, and mulch levels maintained. Planter beds will not be allowed to encroach into turf areas. A definite break shall be maintained between turf areas and planter beds.

3.4.3.1 Shrub Selective Maintenance

In addition to the above requirements, shrubs shall be selectively pruned, and shaped for health and safety when the following conditions exist: Remove growth in front of windows, over entrance ways or walks, and any growth which will obstruct vision at street intersections or of security personnel; Remove dead, damaged or diseased branches or limbs; where shrub growth obstructs pedestrian walkways; where shrub growth is found growing against or over structures; where shrub growth permits concealment of unauthorized persons. All pruning debris shall be disposed of in a proper manner.

3.4.3.2 Tree Maintenance

Tree maintenance shall include adjustment of stakes, ties, guy supports and turnbuckles, watering, fertilizing, pest control, mulching, pruning for health and safety and fall leaf cleanup. Stakes, ties, guy supports and turnbuckles shall be inspected and adjusted to avoid girdling and promote natural development. All trees within the project boundaries, regardless of caliper, shall be selectively pruned for safety and health reasons. This includes, but is not limited to, removal of dead and broken branches and correction of structural defects. Prune trees according to their natural growth characteristics leaving trees well shaped and balanced. Pruning of all trees including palm trees shall be accomplished by or in the presence of a certified member of the International Society of Arboriculture and in accordance with TCIA Z133.1. All pruning debris generated shall be disposed of in a proper manner.

3.4.4 Slope Erosion Control Maintenance

The Contractor shall provide slope erosion control maintenance to prevent undermining of all slopes in newly landscaped and natural growth areas. Maintenance tasks include immediate repairs to weak spots in sloped areas, and maintaining clean, clear culverts, and graded berms, and terraces to intercept and direct water flow to prevent development of large gullies and slope erosion and during periods of extended rainfall, irrigation systems shall be secured. Eroded areas shall be filled with amended topsoil and replanted with the same plant species. Erosion control netting blankets damaged due to slope erosion shall be reinstalled.

3.4.5 Removal of Dying or Dead Plants

Remove dead and dying plants and provide new plants immediately upon commencement of the specified planting season, and replace stakes, guys, mulch and eroded earth mound water basins. No additional plant establishment period will be required for replacement plants beyond the original warranty period. A tree shall be considered dying or dead when the main leader has died back, or a minimum of 20 percent of the crown has died. A shrub or ground cover shall be considered dying or dead when a minimum of 20 percent of the plant has died. This condition shall be determined by scraping on a branch an area 2 mm (1/16 inch) square, maximum, to determine the cause for dying plant material and shall provide recommendations for replacement. The Contractor shall determine the cause for dying plant material and provide recommendations for replacement.

3.4.6 Tracking of Unhealthy Plants

Note plants not in healthy growing condition, as determined by the Contracting Officer, and as soon as seasonal conditions permit, remove and replace with plants of the same species and sizes as originally specified. Install replacement plantings in accordance with Section 32 93 00 EXTERIOR PLANTS.

3.4.7 Final Inspection

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the establishment period. Final inspection will be based upon satisfactory health and growth of plants and on the following:

3.4.7.1 Total Plants on Site

Plants have been accepted and required number of replacements has been planted.

3.4.7.2 Mulching and Weeding

Planter beds and earth mound water basins are properly mulched and free of weeds.

3.4.7.3 Tree Supports

Stakes guys and turnbuckles are in good condition.

3.4.7.4 Remedial Work

Remedial measures directed by the Contracting Officer to ensure plant material survival and promote healthy growth have been completed.

3.5 FIELD QUALITY CONTROL

3.5.1 Maintenance Inspection Report

Provide maintenance inspection report to assure that landscape maintenance is being performed in accordance with the specifications and in the best interest of plant growth and survivability. Site observations shall be documented at the start of the establishment period, then quarterly following the start, and at the end of establishment period. Results of site observation visits shall be submitted to the Contracting Officer within 7 calendar days of each site observation visit.

3.5.2 Plant Quantities

The Contractor shall provide Contracting Officer with the plant quantities. In addition, provide total exterior area of hardscape and landscaping such as turf and total number of shrubs.

3.5.3 Tree Staking and Guying Removal

The Contractor shall provide a certified letter that all stakes and guys are removed from all project trees at the end of the establishment period.

-- End of Section --

SECTION 32 11 10

DRAINAGE LAYER

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 320	(2010) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 102	(2009) Standard Method of Test for Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2172/D2172M	(2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for

	Use in Pavement Construction
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D6307	(2010) Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST IR 91-4756	(1991) Laboratory Accreditation Activities in the United States

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2309	(2009) Standard test method for amount of material in passing standard sieve 0.075mm in soils
KS F 2324	(2006) Method of Classification of Soils for Engineering Purposes
KS F 2354	(2013) Testing method for bitumen content from bituminous paving mixtures
KS F 2389	(2004; R 2009) Specification for performance graded asphalt binder
KS F 2501	(2007) Sampling Aggregate
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2505	(2002) Methods of test for bulk density of aggregates and solid content in aggregates
KS F 2507	(2007) Method of test for soundness of aggregates by use of sodium sulfate
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine
KS F 2575	(2013) Testing method for flat or elongated particles in coarse aggregate
KS L 5201	(2013) Portland Cement

KS M 2208	(2007) Viscosity-Graded asphalt cement for use pavement construction

1.2 SYSTEM DESCRIPTION

Build a drainage layer under the pavements, as indicated on drawings, consisting of Rapid Draining Material (RDM)Open Graded Material stabilized with a choke stoneOpen Graded Material stabilized with cement or bituminous.

1.2.1 Equipment

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times.

1.2.2 Placement Equipment

Use an asphalt paving machine to place drainage layer material. Alternate methods may be used if it can be demonstrated in the test section that these methods obtain the specified results.

1.2.3 Compaction Equipment

Use a dual or single smooth 0.9 ton- (2000 lb-) (min.) vibratory drum roller, which provides a maximum compactive effort without crushing the drainage layer aggregate, to compact drainage layer material.

1.2.4 Bituminous Mixing Plant

Provide a bituminous mixing plant that is an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a bituminous stabilized aggregate mixture consistent with the job-mix formula (JMF).

1.2.5 Cementitious Mixing Plant

Provide a cementitious mixing plant that is an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a cement stabilized aggregate mixture consistent with the job mix formula determined by the Government. Aggregate and cement shall be dry mixed sufficiently to prevent cement balls from forming when water is added.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Sampling and Testing
Approval of Materials; G
Evaluation

1.4 QUALITY ASSURANCE

1.4.1 Sampling and Testing

Submit copies of field test results within 24 hours of completion of tests. Sampling and testing are the responsibility of the Contractor to be performed by an approved commercial testing laboratory, or by the Contractor subject to approval. If the Contractor elects to establish testing facilities of its own, approval of such facilities will be based on compliance with NIST IR 91-4756, and no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved. The first inspection of the facilities will be at the expense of the Government and any subsequent inspections required because of failure of the first inspection shall be at the expense of the Contractor. Such costs will be deducted from the total amount due the Contractor. Test drainage layer materials to establish compliance with the specified requirements.

1.4.2 Sampling

Take aggregate samples in accordance with ASTM D75/D75M or KS F 2501. Take bituminous samples in accordance with ASTM D140/D140M. Take bituminous or cement stabilized mixture samples using methods approved by the Contracting Officer.

1.4.3 Test Methods

1.4.3.1 Sieve Analyses

Make sieve analyses in accordance with ASTM C117 or KS F 2309 and ASTM C136 or KS F 2502.

1.4.3.2 Density Tests

Perform field density tests for RDM drainage layers in accordance with ASTM D6938 by Direct Transmission Method for the full depth of the lift, use ASTM D6938 to determine the moisture content of the aggregate drainage layer material. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph "Calibration" of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed by the Contracting Officer.

1.4.3.3 Soundness Test

Perform soundness tests in accordance with ASTM C88 or KS F 2507.

1.4.3.4 Los Angeles Abrasion Test

Perform Los Angeles abrasion tests in accordance with ASTM C131 or KS F 2508.

1.4.3.5 Flat or Elongated Particles Tests

Perform flat and/or elongated particles tests in accordance with ASTM D4791 or KS F 2575.

1.4.3.6 Fractured Faces Tests

When aggregates are supplied from crushed gravel, use approved test methods to ensure the aggregate meets the requirements for fractured faces in paragraph AGGREGATES.

1.4.3.7 Bitumen Content

Perform bitumen extraction tests in accordance with ASTM D2172/D2172M or KS F 2354 or ignition tests in accordance with ASTM D6307.

1.4.4 Initial Tests

Perform one of each of the following tests on the proposed material, prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, complete the following tests for each source.

a. Sieve Analysis including 75 µm (No. 200 sieve) size material.

b. Flat and/or elongated particles

c. Fractured Faces

d. Los Angeles abrasion.

e. Soundness.

1.4.5 Testing Frequency

1.4.5.1 Aggregate Layer

Perform field density and moisture content tests at a rate of at least one test for every 1,600 square meters (2,000 square yards) of completed area and not less than one test for each day's production. Sieve analyses shall be performed at a rate of at least one test for every 4,900 square meters (6,000 square yards) of completed area. Perform soundness tests, Los Angeles abrasion tests, fractured faces tests and flat and/or elongated particles tests at the rate of one test for every 9,700 square meters (12,000 square yards) of production.

1.4.5.2 Stabilized Layer

Perform sieve analyses on aggregates prior to addition of asphalt or portland cement, at a rate of at least one test for every 4,900 square meters (6,000 square yards) of completed area and not less than one test for each days production. Make extraction tests on bituminous stabilized material at the same frequency. Perform soundness tests, Los Angeles abrasion tests, fractured faces tests, and flat and/or elongated particles tests at the rate of one test for every 9,700 square meters (12,000 square yards) of production.

1.4.6 Approval of Materials

Submit material sources and material test results prior to field use.

1.4.6.1 Aggregate

Select the aggregate source at least 60 days prior to field use in the test section. Tentative approval of the source will be based on certified test results to verify that materials proposed for use meet the contract requirements. Final approval of both the source and the material will be based on test section performance and tests for gradation, soundness, Los Angeles abrasion, flat and/or elongated particles tests and fractured faces tests. For aggregate drainage layer materials, perform these tests on samples taken from the completed and compacted drainage layer course within the test section. For bituminous or cement stabilized drainage layer material, perform these tests on aggregate samples taken prior to addition of bituminous or cementitious material and subsequent placement in the test section.

1.4.6.2 Bituminous or Cementitious Materials

Submit bituminous or cementitious sources and certified material test results for approval not less than 60 days prior to field use in the test section.

1.5 ENVIRONMENTAL REQUIREMENTS

Place drainage layer material when the atmospheric temperature is above 2 degrees C (35 degrees F). Correct areas of completed drainage layer or underlying courses that are damaged by freezing, rainfall, or other weather conditions or by contamination from sediments, dust, dirt, or foreign material to meet specified requirements.

PART 2 PRODUCTS

2.1 GOVERNMENT APPROVAL

Asphalt or cement stabilized material will require Government notification and delivery of approved materials in accordance with paragraph BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA.

2.2 AGGREGATES

Provide aggregates consisting of clean, sound, hard, durable, angular particles of crushed stone, crushed slag, or crushed gravel which meet the specification requirements. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1,040 kg per cubic meter (65 pound per cubic feet) determined by ASTM C29/C29M or KS F 2505. Provide aggregates free of silt and clay as defined by ASTM D2487 or KS F 2324, vegetable matter, and other objectionable materials or coatings.

2.2.1 Aggregate Quality

The aggregate shall have a soundness loss not greater than 18 percent weighted averaged at 5 cycles when tested in magnesium sulfate in accordance with ASTM C88 or KS F 2507 and a percentage of loss on abrasion not to exceed 40 after 500 revolutions as determined by ASTM C131 KS F 2508. Determine the percentage of flat and/or elongated particles by ASTM D4791 or KS F 2575 with the following modifications: 1) The aggregates shall be separated into 2 size fractions, particles greater than 12.5 mm (1/2 inch) sieve and particles passing the 12.5 mm (1/2 inch) sieve and retained on the 4.75 mm (No. 4) sieve. 2) The percentage of flat and/or elongated particles in either fraction shall not exceed 20. 3) A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. 4) When the aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements. When the aggregate is supplied from crushed gravel it shall be manufactured from gravel particles, 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE I. In the portion retained on each sieve specified, the crushed gravel shall contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the face. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as 2 fractured faces.

2.2.2 Gradation Requirements

Drainage layer aggregates must be well graded within the limits specified in TABLE I.

TABLE I. GRADATION OF DRAINAGE LAYER MATERIAL

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid draining Material (RDM)	Open Graded Material (OGM)	Choke Stone	OGM stabilized
37.50 mm (1.5 inch)	100	100	100	100
25.00 mm (1 inch)	70-100	95-100	100	95-100
19.00 mm (3/4 inch)	55-100	---	100	---
12.50 mm (1/2 inch)	40-80	25-80	100	25-80
9.50 mm (3/8 inch)	30-65	---	80-100	---
4.75 mm (No. 4)	10-50	0-10	10-100	0-10
2.36 mm (No. 8)	0-25	0-5	5-40	0-5
1.18 mm (No. 16)	0-5	---	0-10	---

NOTE 1: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

NOTE 2: Choke stone is required to stabilize the OGM for constructability of the overlying layer. If approved by the COR, the OGM can be constructed without choke stone, provided equipment is not operated on the finished surface of the OGM. Choke stone shall be made up of hard, durable, crushed aggregate having 90 percent of the stone with fractured faces. The gradation for the choke stone shall be based on the following criteria:

a. The ratio of the D15 of the OGM to the D15 of the choke stone shall be less than 5.

b. The ratio of the D50 of the OGM to the D50 of the choke stone shall be greater than 2.

NOTE 3: For RDM, the coefficient of uniformity (CU) shall be greater than 3.5. (CU = D60/D10). The Contractor is responsible for adjusting the RDM gradation within the ranges listed in Table I to provide a stable construction surface for the proposed equipment and method of transporting materials or the drainage layer can be stabilize with portland cement or asphalt at no additional cost to the government, if approved during the test section.

NOTE 4: Asphalt cement or portland cement will be required to stabilize the OGM.

2.3 BITUMINOUS MATERIALS

Asphalt cement to be mixed with aggregates shall conform to ASTM D946/D946M Penetration Grade 85-100 or 60-70 ASTM D3381/D3381M or KS M 2208 viscosity Grade AASHTO M 320 PG or KS F 2389 PG . In addition, the asphalt cement shall show a negative spot when subjected to the spot test in accordance with AASHTO T 102, using the standard naphtha specified.

2.4 CEMENTITIOUS MATERIALS

Portland cement to be mixed with aggregates shall conform to

ASTM C150/C150M, Type I, IA, II or IIA or KS L 5201 Class I or II.

2.5 BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA

The bituminous stabilized mix shall consist of a mixture of OGM and a minimum of 2 percent asphalt cement by weight. Tolerances for bituminous stabilized material shall be maintained for field production at plus or minus 0.25 percent for asphalt cement and plus or minus 14 degrees C (57 degrees F) for mixing temperatures. The cement stabilized mix shall consist of OGM and a minimum of 90 kg (200 pounds) of portland cement per cubic meters (cubic yards) with a water/cement ratio of 0.37. Based on the test section performance, the Contractor shall be responsible for adjustments (increases) in asphalt cement or portland cement quantities to ensure the stabilized drainage layer will not rut or be disturbed by the Contractor's proposed paving method. Submit a job-mix formula (JMF) with the test section report for Contracting Officer approval.

PART 3 EXECUTION

3.1 STOCKPILING AGGREGATES

Stockpile aggregates at locations designated by the Contracting Officer. Clear and level stockpile areas prior to stockpiling aggregates to prevent segregation and contamination. Separately stockpile aggregates obtained from different sources.

3.2 TEST SECTION

3.2.1 Data

Construct a test section to evaluate the ability to carry traffic, including placement of overlaying material and the constructability of the drainage layer including required mixing, placement, and compaction procedures. Test section data will be used by the Contracting Officer to validate the required number of compaction passes given in paragraph Compaction Requirements and the field dry density requirements for full scale production.

3.2.2 Schedule/Evaluation

Construct the test section a minimum of 30 days prior to the start of full scale production to provide sufficient time for an evaluation of the proposed materials, equipment and procedures including Government QA testing.

3.2.3 Location and Size

Place the test section outside production paving limits in an area with similar subgrade and subbase conditions approved by the Contracting Officer. The underlying courses and subgrade preparation, required for the pavement section, shall be completed, inspected and approved in the test section prior to constructing the drainage layer. The test section shall be a minimum of 30 m (100 feet) long and two full paving lanes wide side by side.

3.2.4 Initial Testing

Provide certified test results, approved by the Contracting Officer prior to the start of the test section, to verify that the materials proposed for use in the test section meet the contract requirements.

3.2.5 Mixing, Placement, and Compaction

Accomplish mixing, placement, and compaction using equipment meeting the requirements of paragraph EQUIPMENT. Compaction equipment speed shall be no greater than 2.4 km/hour (1.5 mph). Start compaction from the outside edges of the paving lane and proceed to the centerline of the lift being placed. The roller shall stay a minimum of one half the roller width from the outside edge of the drainage layer being placed until the desired density is obtained. The outside edge shall then be rolled.

3.2.6 Procedure

3.2.6.1 RDM Aggregate Drainage Layer Tests

Construct the test section with aggregate in a wet state so as to establish a correlation between number of roller passes and dry density achievable during field production. Designate three separate areas within the test section, test each area for density, moisture, and gradation. Complete all testing in the middle third of the test section being placed. Conduct density and moisture content tests in accordance with ASTM D6938. Conduct sieve analysis tests on samples, taken adjacent to the density test locations. Take one set of tests (i.e. density, moisture, and sieve analysis) before the third compaction pass and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Define a pass as the movement of a roller over the drainage layer area for one direction only. Compaction for the RDM shall consist of a maximum of 5 passes in the vibrating state and one final pass in the static state. Continue compaction passes and density readings until the difference between the average dry densities of any two consecutive passes is less than or equal to 16 kg per cubic meter (1.0 pound per cubic feet).

3.2.6.2 Bituminous/Cement Stabilized Drainage Layer

Construct the test section with the same equipment used for production. Designate three separate areas within the test section for sampling. Complete all testing in the middle third of the test section being placed. The Contracting Officer will perform visual examination of each sample to determine if and when crushing of aggregate occurs. Take one sample before compaction and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Continue compaction for a maximum of 6 passes. Define a pass as the movement of a roller over the drainage layer area for one direction only. Placement procedures and equipment shall be as described herein. The Contracting Officer will determine the number of passes required for compaction from the test section.

3.2.6.3 OGM with Choke Stone

Construct the test section with aggregate in a moist state. When the OGM gradation is used, density testing is not required, only gradation testing is required. Designate three separate areas within the test section for sampling. Complete all testing in the middle third of the test section being placed. The maximum number of passes per lift shall be 8. Define a pass as the movement of a roller over the drainage layer area for one direction only. Placement procedures and equipment will be as described herein. Conduct sieve analysis tests on samples. Take one set of sieve tests before the third compaction pass and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Compaction for the OGM shall consist of first 5 passes in the vibrating state and one final pass in the static state. The Contracting Officer will determine the number of passes required for production from the results of the test section. If choke stone is used to stabilize the surface of OGM, place the choke stone after final static compaction of the OGM. Spread the choke stone in a thin layer no thicker than 13 mm (1/2 inch) and worked into the surface of the OGM using two additional passes of a vibratory roller and wetting. Sieve testing is not required after the compaction of the choke stone.

3.2.7 Evaluation

Within 10 days of completion of the test section, submit to the Contracting Officer a Test Section Construction Report complete with all required test data and correlations. The Contracting Officer will evaluate the data and validate the required number of passes of the roller, the need for a final static pass of the roller, and provide the dry density for field density control during construction.

3.3 PREPARATION OF UNDERLYING COURSE

Prior to constructing the drainage layer, clean the underlying course of all foreign materials. During construction, the underlying course shall contain no frozen material. The underlying course shall conform to Section 32 11 16 BASE COURSE FOR RIGID AND SUBBASES FOR FLEXIBLE PAVING. Correct ruts or soft yielding spots in the underlying courses having inadequate compaction and deviations of the surface from the requirements set forth herein by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line, and grade, and recompacting to specified density. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the drainage layer is placed.

3.4 TRANSPORTING MATERIAL

3.4.1 Aggregate Drainage Layer Material

Transport aggregate drainage layer material to the site in a manner which prevents segregation and contamination of materials.

3.4.2 Bituminous Stabilized Material

Transport bituminous stabilized material from the mixing plant to the site in trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of the stabilized material to the truck beds. Drain excessive releasing agent prior to loading. Cover each load with canvas or other approved material of ample size to protect the stabilized material from the weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or have become wet will be rejected. Hauling over freshly placed material will not be permitted.

3.4.3 Cement Stabilized Material

Transport cement stabilized material from the mixing plant to the site in trucks equipped with protective covers. Loads that have crusts of unworkable material or have become excessively wet will be rejected.

Hauling over freshly placed material will not be permitted.

3.5 PLACING

3.5.1 General Requisites

Place drainage layer material on the underlying course in lifts of uniform thickness using equipment meeting the requirements of paragraph EQUIPMENT. When a compacted layer 150 mm (6 inches) or less in thickness is required, place the material in a single lift. When a compacted layer in excess of 150 mm (6 inches) is required, place the material in lifts of equal thickness. No lift shall exceed 150 mm (6 inches) or be less than 75 mm (3 inches) when compacted. The lifts when compacted after placement shall be true to the grades or levels required with the least possible surface disturbance. Where the drainage layer is placed in more than one lift, clean the previously constructed lift of loose and foreign material. Such adjustments in placing procedures or equipment shall be made to obtain true grades and minimize segregation and degradation of the drainage layer material. Spread choke stone used to stabilize the surface of the OGM in a thin layer no thicker than 13 mm (1/2 inch). The OGM shall be brought to grade and the choke stone placed and rolled as described in paragraph; TEST SECTION.

3.5.2 Placement of Stabilized Material

Bituminous stabilized material having temperatures less than 80 degrees C (175 degrees F) when dumped into the asphalt paving machine will be rejected. Adjust the paving machine so that the surface of the lift being laid will be smooth and continuous without tears and pulls. Correct irregularities in alignment of the lift left by the paving machine by trimming directly behind the machine. Immediately after trimming, thoroughly compact the edges of the lift by a method approved by the Contracting Officer. Distortion of the lift during tamping will not be permitted. If more than one lift is required, offset the longitudinal joint in one lift that in the lift immediately below by at least 300 mm (1 feet); however, the joint in the top layer shall be at the centerline of the pavement. Offset transverse joints in one layer by at least 600 mm (2 feet) from transverse joints in the previous layer. Transverse joints in adjacent strips shall be offset a minimum of 3 meters (10 feet). At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face free of loose or shattered material. Remove material along construction joints not properly compacted.

3.5.3 Placing Adjacent Stabilized Strips

Place the stabilized material in consecutive adjacent strips having a minimum width of 3 meters (10 feet), except where edge lanes require strips less than 3 meters (10 feet) to complete the area. In placing adjacent strips, the screed of the paving machine shall overlap the previously placed strip 75 to 100 mm (3 to 4 inches) and shall be sufficiently high so that compaction will produce a smooth, dense joint. The stabilized material placed on the edge of the previously placed strip by the paver shall be pushed back to the edge of the strip being placed. Remove and waste excess stabilized material.

3.5.4 Hand Spreading

Spread by hand drainage layer material in areas where machine spreading is impractical. The material shall be spread uniformly in a loose layer to prevent segregation. The material shall conform to the required grade and thickness after compaction.

3.6 COMPACTION REQUIREMENTS

3.6.1 Field Compaction

Base field compaction requirements on the results of the test section, using the materials, methods, and equipment proposed for use in the work.

3.6.2 Number of Passes

Accomplish compaction using rollers meeting the requirements of paragraph EQUIPMENT and operating at a rolling speed of no greater than 2.4 km (1.5 miles) per hour. Compact each lift of drainage material, including shoulders when specified under the shoulders, with the number of passes of the roller as follows: for RDM material use 4 passes in the vibratory state and one in the static. For cement or Bituminous stabilized OGM material use 3 passes in the vibratory state and one in the static state. For OGM stabilized with choke stone use 4 passes in the vibratory state on OGM and 2 additional roller passes on the choke stone in the vibratory state with wetting. The Contracting Officer will validate the number of roller passes after the test section is evaluated and before production starts.

3.6.3 Dry Density

In addition, maintain a minimum field dry density as specified by the Contracting Officer. If the required field dry density is not obtained, adjust the number of roller passes in accordance with paragraph DEFICIENCIES. Compact aggregate in a moisture state as determined in the test section. Excessive rolling resulting in crushing of aggregate particles shall be avoided. Choke stone used to stabilize the surface of the OGM shall be worked into the surface of the OGM by two passes of a vibratory roller and wetting. Begin compaction of bituminous stabilized material immediately when the material has cooled to 77 degrees C (170 degrees F). Not more than 30 minutes shall elapse between the start of moist mixing of cement stabilized material and the start of field compaction, which shall be completed within 60 minutes. In all places not accessible to the rollers, compact the drainage layer material with mechanical hand operated tampers.

3.7 FINISHING

Finish the top surface of the drainage layer after final compaction, as determined from the test section. Make adjustments in rolling and finishing procedures to obtain grades and minimize segregation and degradation of the drainage layer material.

3.8 CURING OF CEMENT STABILIZED MATERIAL

Cure the completed cement stabilized drainage layer with water for a period of 12 hours following completion of compaction. Commence curing operations within 3 hours after compaction. Curing shall consist of one of the following: 1) Sprinkling the surface of the drainage layer with a fine spray of water every 2 hours for the required 12 hour period, 2) by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap, 3) Impervious sheet curing. Curing water shall be applied so that the cement paste on the surface of the mixture will not be eroded. Water trucks will not be permitted on the completed cement stabilized drainage layer. Impervious sheeting curing shall consist of all surfaces being thoroughly wetted and then completely covered with the sheeting. Sheeting shall be at least 450 mm (18 inches) wider than the stabilized drainage layer surface to be covered. Lay covering with light-colored side up. Lap covering not less than 300 mm (12 inches); securely weight covering to prevent displacement so that it remains in contact with the surface during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears of holes appear during the curing period

3.9 EDGES OF DRAINAGE LAYER

Place shoulder material along the edges of the drainage layer course in a quantity that will compact to the thickness of the layer being constructed. At least 1 m (3 feet) width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each lift of the drainage layer.

3.10 SMOOTHNESS TEST

The surface of the top lift shall not deviate more than 10 mm(3/8 inch) when tested with either a 3.05 or 3.66 m (10 or 12 feet) straightedge applied parallel with and at right angles to the centerline of the area to be paved. Correct deviations exceeding 10 mm (3/8 inch) in accordance with paragraph DEFICIENCIES.

3.11 THICKNESS CONTROL

The completed thickness of the drainage layer shall be within 13 mm (1/2 inch)of the thickness indicated. Measure thickness at intervals providing at least one measurement for each 400 square meters (500 square yards) of drainage layer. Make measurements in test holes at least 75 mm (3 inches) in diameter unless the Contractor can demonstrate, for COR approval, that a steel rod pushed through the drainage layer clearly stops at the material interface. Where the measured thickness is more than 13 mm (1/2 inch) deficient, such areas shall be corrected in accordance with paragraph DEFICIENCIES. Where the measured thickness is 13 mm (1/2 inch) more than indicated, it will be considered as conforming to the requirements plus 13 mm (1/2 inch), provided the surface of the drainage layer is within 13 mm (1/2 inch) of established grade. The average job thickness shall be the average of all job measurements as specified above but within 8 mm (1/4 inch) of the thickness shown on the drawings.

3.12 DEFICIENCIES

3.12.1 Grade and Thickness

Correct deficiencies in grade and thickness so that both grade and thickness tolerances are met. Thin layers of material shall not be added to the top surface of the drainage layer to meet grade or increase thickness. If the elevation of the top of the drainage layer is more than 13 mm (1/2 inch) above the plan grade it shall be trimmed to grade and finished in accordance with paragraph FINISHING. If the elevation of the top surface of the drainage layer is 13 mm (1/2 inch) or more below the required grade, the surface of the drainage layer shall be scarified to a depth of at least 75 mm (3 inches), new material shall be added, and the layer shall be blended and recompacted to bring it to grade. Where the measured thickness of the drainage layer is more than 13 mm (1/2 inch) deficient, such areas shall be corrected by excavating to the required depth and replaced with new material to obtain a compacted lift thickness of at least 75 mm (3 inches). The depth of required excavation shall be controlled to keep the final surface elevation within grade requirements and to preserve layer thicknesses of materials below the drainage layer.

3.12.2 Density

Density is considered deficient if the field dry density test results are below the dry density specified by the Contracting Officer. If the densities are deficient, roll the layer with two additional passes of the specified roller. If the dry density is still deficient, stop work until the cause of the low dry densities can be determined and reported to the Contracting Officer.

3.12.3 Smoothness

Correct deficiencies in smoothness as if they are deficiencies in grade or thickness. Maintain all tolerances for grade and thickness while correcting smoothness deficiencies.

-- End of Section --

SECTION 32 11 16.16

BASE COURSE FOR RIGID AND SUBBASE COURSE FOR PERVIOUS PAVING
11/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1883	(2007; E 2009; E 2009) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2940/D2940M	(2009) Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5106	(2008) Steel Slag Aggregates for Bituminous Paving Mixtures
ASTM D6155	(2006) Nontraditional Coarse Aggregate for Bituminous Paving Mixtures
ASTM D6270	(2008e1) Use of Scrap Tires in Civil Engineering Applications

ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates

1.2 RELATED SECTIONS

Pervious pavement systems shall use Section 32 11 24 GRADED CRUSHED AGGREGATE BASE COURSE FOR FLEXIBLE PAVEMENT and Section 32 12 10 BITUMINOUS TACK AND PRIME COATS, in addition to this section.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-05 Design Data

Gradation curve

SD-06 Test Reports

Bearing ratio

Liquid limit

Plasticity index

Dry weight of slag

Percentage of wear

Gradation tests

Density tests

Materials

Geotextile

SD-07 Certificates

Source

Location and name.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site and store aggregates in a manner that will prevent segregation and contamination.

1.5 CONSTRUCTION EQUIPMENT

Subject to approval of the Contracting Officer, special equipment as dictated by local conditions may be used. Calibrated equipment, such as scales, batching equipment, spreaders, and other similar equipment, shall have been calibrated by a calibration laboratory approved by the Contracting Officer within 12 months of commencing work.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not construct course when atmospheric temperature is below 1.5 degrees C (35 degrees F) or when weather conditions could detrimentally affect quality of finished course. When temperature falls below 1.5 degrees C (35 degrees F), protect areas of completed course against freezing.

PART 2 PRODUCTS

2.1 MATERIALS

ASTM D2940/D2940M, except as modified herein. Material shall consist of natural, processed or blends of waste concrete, masonry, cement, tile, or other waste material from on-site work as specified; rock, crushed concrete, concrete block, or crushed slag from off-site grading or demolition work; recycled porcelain, concrete, stone, or other recycled material complying with ASTM D6155; Class I orClass II Fill tire complying with ASTM D6270; steel slag complying with ASTM D5106; gravel; stone; slag; chert; caliche; limerock; coral; shell; quarry and mine waste; sand; or screenings; and soil or other similar binding or filler material. Material shall contain a minimum of 5 percent post-consumer recycled content, or a minimum of 20 percent post-industrial recycled content, and shall be free-draining. Material may contain post-consumer or post-industrial recycled content. Obtain materials from sources approved by the Contracting Officer. Preliminary approval of pits shall not mean that material found in the deposit will be acceptable. Maximum dimensions of material particles shall not be greater than two-thirds the compacted thickness of the layer in which it is to be placed. Coarse aggregate shall have a percentage of wear of not more than 40 as determined by ASTM C131. Material shall have a bearing ratio of at least 30 as determined by laboratory test on a four day soaked specimen in accordance with ASTM D1883; compact the specimen in accordance with ASTM D1557, Method B, C, or D. Material passing the 425 micrometers (No. 40) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 5 in accordance with ASTM D4318. Slag shall be an air-cooled blast furnace product having a dry weight not less than 1041 kg per cubic meter (65 pounds per cubic foot) when tested in accordance with ASTM C29/C29M and consisting of angular fragments uniform in density and quality and reasonably free from thin and elongated pieces, dirt, or other objectionable material. Grading shall be a minimum of 19 mm (3/4 inch) and a maximum of 38 mm (1.5 inches).Gradation of the final composite mixture shall conform to the following size and shall be the basis of the gradation curve:

Sieve Size (Square Openings)	Design Range (Percent Passing)	Job Mix Tolerance (Percent)
50 mm (2 inch)	100	-3
38 mm (1 1/2 inch)	90-100	+5
4.75 mm (No. 4)	30-60	±10
75 mm (No. 200)	0-15	+5

2.2 SOURCE QUALITY CONTROL

Prior to production and delivery of aggregates, take at least one initial sample in accordance with ASTM D75/D75M. Collect each sample by taking three incremental samples at random from source material to make a composite sample of not less than 22 kg (50 pounds). Repeat sampling procedure when source of material is changed or when deficiencies or variations from specified grading of materials are found in testing.

2.2.1 Geotextile

Fabricated from 100 percent post-consumer recycled plastic.

PART 3 EXECUTION

3.1 GRADE CONTROL

Provide line and grade stakes for control. Place grade stakes in lanes parallel to centerline of areas to be paved and space for string lining or other control methods.

3.2 PLACING AND MIXING

Clean underlying surface of foreign substances and ensure proper compaction and smoothness before placement of course. Verify subsoils have a permeability between 13 and 74 mm (0.5 and 3.0 inches) per hour. Recondition, reshape, and recompact areas damaged by freezing, rainfall, or other weather conditions. Place geotextiles in accordance with specifications and drawings. Mix and place materials to obtain a uniform course for the water content and gradation specified. Construct course in one or more layers. Make each layer between 75 and 200 mm (3 and 8 inches) in compacted thickness. Tire shall be installed in accordance with ASTM D6270.

3.3 COMPACTING AND FINISHING

Compact each layer to at least 95 percent of the maximum laboratory density determined in accordance with ASTM D1557 for areas subject to heavy vehicular traffic. Compact each layer to at least 95 percent Standard Proctor Density per ASTM D698 for pedestrian areas. Compact material inaccessible to rolling equipment by mechanical tamping. Finish surface of the layer by blading and rolling. Blade, roll, and tamp until surface is smooth and free from waves and irregularities. Aerate material excessively moistened by rain during construction. Aerate using blade graders, harrows, or other equipment until the moisture content is that needed to obtain specified density. Place and compact earth at edges of course for at least 300 mm (one foot) of the shoulder.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling During Construction

Take one random sample of each 1000 metric tons (1000 tons) of material placed, but not less than one random sample per day's run. Take samples in accordance with ASTM D75/D75M.

3.4.2 Testing

3.4.2.1 Material

Make gradation tests from each sample in accordance with ASTM C136. Determine material passing the 75 micrometers (No. 200) sieve in accordance with ASTM C117.

3.4.2.2 Smoothness Test

Test with a 3 m (10 foot) straightedge applied parallel with and at right angles to centerline of the rolled area. Correct surface deviations in excess of 10 mm (3/8 inch) by loosening, adding or removing material, reshaping, watering, and compacting. When course is constructed in more than one layer, smoothness requirements apply only to the top layer.

3.4.2.3 Field Density Tests

ASTM D1556 or ASTM D6938. Take one field density test for each 400 square meters (500 square yards) of each layer of course. When using ASTM D6938 to test field compaction densities, verify the results of the tests by performing one test per day using ASTM D1556 at locations previously tested by ASTM D6938 and one additional test using ASTM D1556 for every ten tests performed at locations previously tested by ASTM D6938 .

3.4.2.4 Laboratory Density Tests

ASTM D1557, Method B, C, or D, for all material.

3.4.2.5 Thickness Test

Determine thickness of course from test holes not less than 75 mm (3 inches) in diameter. Obtain a thickness test for each 400 square meters (500 square yards) of course. Where course deficiency is more than 13 mm (1/2 inch), correct by scarifying, adding mixture of proper gradation, reblading, and recompacting. Where the measured thickness exceeds the indicated thickness by more than 13 mm (1/2 inch), consider the measured thickness as the indicated or specified thickness plus 13 mm (1/2 inch) for determining the average. The average thickness shall be the average of the depth measurements and shall not under run the thickness shown by more than 6 mm (1/4 inch).

3.5 MAINTENANCE

After construction is completed, protect and maintain all areas of course against detrimental effects. Maintenance includes drainage, rolling, shaping, watering, or other action required to maintain course in proper condition. Maintain sufficient moisture by light sprinkling with water at the surface to prevent a dusty condition.

-- End of Section --

SECTION 32 11 16

SUBBASES FOR FLEXIBLE PAVING
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2010) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM E11	(2009; E 2010) Wire Cloth and Sieves for Testing Purposes

KOREAN INDUSTRIAL STANDARDS (KS)

KS A 5101-1	(2004) Test sieves-Part 1: Test sieves of metal wire mesh
KS F 2302	(2002) Test Method for Particle Size Distribution of Soils
KS F 2303	(2000) Test Method for Liquid Limit and Plastic Limit of Soils
KS F 2309	(2009) Standard test method for amount of material in passing standard sieve 0.075mm in soils
KS F 2311	(2001) Test Method for Soil Density by the Sand Replacement Method
KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F 2324	(2006) Method of Classification of Soils for Engineering Purposes
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method
KS F 2501	(2007) Sampling Aggregate
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2505	(2002) Methods of test for bulk density of aggregates and solid content in aggregates
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine

1.2 DEFINITION

Degree of compaction required is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 or KS F 2312 abbreviated as a percent of laboratory maximum dry density. One exception is as follows: Since ASTM D1557 or KS F 2312 applies only to soils that have 30 percent or less by weight of their particles retained on the 9.0 mm (3/4 inch) sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 9.0 mm (3/4 inch) sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SYSTEM DESCRIPTION

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide equipment which is adequate and has the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment

List of proposed equipment to be used in performance of construction work, including descriptive data.

SD-06 Test Reports

Initial Tests
In-Place Tests
SMOOTHNESS TEST

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor, to be performed by an approved testing laboratory in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Perform tests at the specified frequency. Test the materials to establish compliance with the specified requirements. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of test sampling.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M or KS F 2501. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analysis

Make sieve analysis in conformance with ASTM C117 or KS F 2309 and ASTM C136 or KS F 2502. Complete particle-size analysis of the soils in conformance with ASTM D422. Sieves shall conform to ASTM E11 or KS A 5101-1.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318 or KS F 2303.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with ASTM D1557 or KS F 2312 or AASHTO T 180, Method D and corrected with AASHTO T 224.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556 or KS F 2311, ASTM D2167 or KS F 2347, or ASTM D6938.

a. Submit certified copies of test results for approval not less than 30 days before material is required for the work.

b. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

c. Submit copies of field test results within 24 hours after the tests are performed.

1.5.2.5 Wear Test

Perform wear tests in conformance with ASTM C131 or KS F 2508.

1.5.2.6 Weight of Slag

Determine weight per cubic meter (foot) of slag in accordance with ASTM C29/C29M or KS F 2505.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

Perform one of each of the following tests on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation.

a. Sieve Analysis including 0.02 mm size material
b. Liquid limit and plasticity index
c. Moisture-density relationship
d. Wear
e. Weight per cubic meter (foot) of Slag

1.5.3.2 In-Place Tests

Perform one of each of the following tests on samples taken from the placed and compacted subbase and select-material subbase or rigid pavement base course. Samples shall be taken and tested at the rates indicated.

a. Perform density tests on every lift (layer) of material placed and at a frequency of one set of tests for every 500 square meters (yards), or portion thereof, of completed area.

b. Perform sieve analysis including 0.02 mm size material on every lift (layer) of material placed and at a frequency of one sieve analysis for every 1000 square meters yards), or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the thickness of each course at intervals providing at least one measurement for each 500 square meters (yards) or part thereof. The thickness measurement shall be made by test holes, at least 75 mm (3 inches) in diameter through the course.

1.5.4 Approval of Material

Select the source of materials 30 days prior to the time the material will be required in the work. Tentative approval will be based on initial test results. Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and compacted course.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 2 degrees C (35 degrees F). When the temperature falls below 2 degrees C (35 degrees F), protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Subbase Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the 4.75 mm (No. 4) sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C131 or KS F 2508. Aggregate shall be reasonably uniform in density and quality. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1050 kg/cubic meter (65 pcf). Aggregates shall be within the limits specified as follows:

Sieve Designation	Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve No. 1	No. 2	No. 3
2 mm	50	80	100
0.075 mm	8	8	8

Sieve Designation	Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve No. 1	No.2	No. 3
No. 10	50	80	100
No. 200	8	8	8

Particles having diameters less than 0.02 mm (0.0008 inches) shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D422 or KS F 2302. The portion of any blended component and of the completed course passing the 0.425 mm (No. 40 sieve) shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.1.2 Select-Material Subbase Course

Provide materials consisting of selected soil or other materials from field excavation, stockpiles, or other sources and free from lumps and balls of clay and from organic and other objectionable matter. Not more than 25 percent by weight shall pass the 0.075 mm (No. 200) sieve. The portion of material passing the 0.425 mm (No. 40) sieve shall have a liquid limit less than 35 and a plasticity index less than 12. The maximum particle size shall not exceed 75 mm (3 inches). Particles having diameters less than 0.02 mm shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D422 or KS F 2302.

2.1.3 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the 4.75 mm (No. 4) sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C131 or KS F 2508. At least 50 percent by weight retained on each sieve shall have one freshly fractured face with the area at least equal to 75 percent of the smallest midsectional area of the piece. Aggregate shall be reasonably uniform in density and quality. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1050 kg/cubic meter (65 pcf). Aggregates shall have a maximum size of 50 mm (2 inches) and shall be within the limits specified as follows:

Sieve Designation	Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve Rigid Pavement Base Course
2 mm	85
0.075 mm	8

Sieve Designation	Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve Rigid Pavement Base Course
No. 10	85
No. 200	8

Particles having diameters less than 0.02 mm shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D422 or KS F 2302. The portion of any blended component and of the completed course passing the 0.425 mm (No. 40 sieve) shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5. The Contractor is responsible for any additional stability required to provide a working platform for construction equipment. If the Contractor can demonstrate with a test section that a material has adequate stability to support construction equipment, the fractured face requirement can be deleted, subject to the approval of the Contracting Officer.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Clearing, stripping and excavating are the responsibility of the Contractor. Operate the aggregate sources to produce the quantity and quality of materials meeting the specified requirements in the specified time limit. Aggregate sources on private lands shall be conditioned in agreement with local laws and authorities.

3.2 STOCKPILING MATERIAL

Prior to stockpiling of material, clear and level storage sites. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.3 PREPARATION OF UNDERLYING MATERIAL

Prior to constructing the subbase, select-material subbase, orrigid pavement base course, clean the underlying course or subgrade of all foreign substances. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. Correct ruts, or soft yielding spots, in the underlying courses, subgrade areas having inadequate compaction, and deviations of the surface from the specified requirements, by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487 or KS F 2324, the surface shall be stabilized prior to placement of the overlying course. Accomplish stabilization by mixing the overlying course material into the underlying course, and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements for the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the overlying course is placed.

3.4 GRADE CONTROL

The finished and completed course shall conform to the lines, grades, and cross sections shown. The lines, grades, and cross sections shown shall be maintained by means of line and grade stakes placed by the Contractor at the work site.

3.5 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material at the water content specified. Make such adjustments in mixing or placing procedures or in equipment as may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory subbase course.

3.6 LAYER THICKNESS

The compacted thickness of the completed course shall be as indicated. When a compacted layer of 150 mm (6 inches) is specified, the material may be placed in a single layer; when a compacted thickness of more than 150 mm (6 inches) is required, no layer shall be thicker than 150 mm (6 inches) nor be thinner than 75 mm (3 inches) when compacted.

3.7 COMPACTION

Compact each layer of the material, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of optimum water content, as determined from laboratory tests, as specified in paragraph SAMPLING AND TESTING. In all places not accessible to the rollers, compact the mixture with hand-operated power tampers. Compaction of the subbase or select-material subbase shall continue until each layer is compacted through the full depth to at least 100 percent of laboratory maximum density. Compaction of the rigid base course shall continue until each layer is compacted through the full depth to at least 95 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory subbase course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.8 PROOF ROLLING

Areas designated on the drawings to be proof rolled shall receive an application of 30 coverages with a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 13.6 metric tons (30,000 pounds) and inflated to a minimum of 1.034 MPa (125 psi). A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top layer of the subbase course. Maintain water content of the top layer of the subbase course such that the water content is within plus or minus 2 percent of optimum water content, as determined from laboratory tests, as specified in paragraph SAMPLING AND TESTING. Any material in the subbase courses or underlying materials indicated to be unsatisfactory by the proof rolling shall be removed, dried, and recompacted, or removed and replaced with satisfactory materials.

3.9 EDGES

Place approved material along the edges of the subbase and select-material subbase course in such quantity as will compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least a 300 mm (1 foot) width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the subbase course, as directed.

3.10 SMOOTHNESS TEST

The surface of the top layer shall show no deviations in excess of 10 mm (3/8 inch) when tested with a 3.66 m (12 foot) straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 15 meter (50 foot) intervals. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.11 THICKNESS CONTROL

The completed thickness of the course(s) shall be in accordance with the thickness and grade indicated on the drawings. The completed course shall not be more than 13 mm (1/2 inch) deficient in thickness nor more than 13 mm (1/2 inch) above or below the established grade. Where any of these tolerances are exceeded, correct such areas by scarifying, adding new material of proper gradation or removing material, and compacting, as directed. Where the measured thickness is 13 mm (1/2 inch) or more thicker than shown, the course will be considered as conforming with the specified thickness requirements plus 13 mm (1/2 inch). The average job thickness shall be the average of the job measurements as specified above but within 6 mm (1/4 inch) of the thickness shown.

3.12 MAINTENANCE

Maintain the completed course in a satisfactory condition until accepted.

-- End of Section --

SECTION 32 11 23

AGGREGATE AND/OR GRADED-CRUSHED AGGREGATE BASE COURSE
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2010) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5821	(2001; R 2006) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM E11	(2009; E 2010) Wire Cloth and Sieves for Testing Purposes

KOREAN INDUSTRIAL STANDARDS (KS)

KS A 5101-1	(2004) Test sieves-Part 1: Test sieves of metal wire mesh
KS F 2302	(2002) Test Method for Particle Size Distribution of Soils
KS F 2303	(2000) Test Method for Liquid Limit and Plastic Limit of Soils
KS F 2311	(2001) Test Method for Soil Density by the Sand Replacement Method
KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F 2324	(2006) Method of Classification of Soils for Engineering Purposes
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method
KS F 2503	(2007) Testing method for density and absorption of coarse aggregate

KS F 2504	(2007) Testing method for density and absorption of fine aggregates
KS F 2505	(2002) Methods of test for bulk density of aggregates and solid content in aggregates
KS F 2507	(2007) Method of test for soundness of aggregates by use of sodium sulfate
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction. GCA is similar to ABC, but it has more stringent requirements and it produces a base course with higher strength and stability.

1.2.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 or KS F 2312 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 or KS F 2312 applies only to soils that have 30 percent or less by weight of their particles retained on the 19.0 mm (3/4 inch) sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 19.0 mm (3/4 inch) sieve are expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SYSTEM DESCRIPTION

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide adequate equipment having the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools

SD-06 Test Reports

Initial Tests
In-Place Tests
SMOOTHNESS TEST

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor and performed by a testing laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Test the materials to establish compliance with the specified requirements; perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of test sampling.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

Perform the following tests in conformance with the applicable standards listed.

1.5.2.1 Sieve Analysis

Make sieve analysis in conformance with ASTM C117 and ASTM C136. Sieves shall conform to ASTM E11 or KS A 5101-1. Particle-size analysis of the soils shall also be completed in conformance with ASTM D422 or KS F 2302.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318 or KS F 2303.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with AASHTO T 180, Method D and corrected with AASHTO T 224.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556 or KS F 2311, ASTM D2167 or ASTM D6938 or KS F 2347.

a. Submit certified copies of test results for approval not less than 30 days before material is required for the work.

b. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

c. Submit copies of field test results within 24 hours after the tests are performed.

1.5.2.5 Wear Test

Perform wear tests on ABC and GCA course material in conformance with ASTM C131 or KS F 2508.

1.5.2.6 Soundness

Perform soundness tests on GCA in accordance with ASTM C88 or KS F 2507.

1.5.2.7 Weight of Slag

Determine weight per cubic meter (foot) of slag in accordance with ASTM C29/C29M or KS F 2505 on the ABC and GCA course material.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis including the 0.02 mm (No. 635) sieve.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Soundness.

f. Weight per cubic meter (foot) of Slag.

1.5.3.2 In Place Tests

Perform each of the following tests on samples taken from the placed and compacted ABC and GCA. Samples shall be taken and tested at the rates indicated.

a. Perform density tests on every lift (layer) of material placed and at a frequency of one set of tests for every 250 square meters (250 square yards), or portion thereof, of completed area.

b. Perform sieve analysis including the 0.02 mm (No. 635) sieve on every lift (layer) of material placed and at a frequency of one sieve analysis for every 500 square meters (500 square yards) , or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the total thickness of the base course at intervals, in such a manner as to ensure one measurement for each 500 square meters (yards) of base course. Measurements shall be made in 75 mm (3 inch) diameter test holes penetrating the base course.

1.5.4 Approval of Material

Select the source of the material 30 days prior to the time the material will be required in the work. Tentative approval of material will be based on initial test results. Final approval of the materials will be based on sieve analysis, liquid limit, and plasticity index tests performed on samples taken from the completed and fully compacted course(s).

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 2 degrees C (35 degrees F). When the temperature falls below 2 degrees C (35 degrees F), protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide ABC and GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, crushed recycled concrete, angular sand, or other approved material. ABC shall be free of lumps of clay, organic matter, and other objectionable materials or coatings. GCA shall be free of silt and clay as defined by ASTM D2487 or KS F 2324, organic matter, and other objectionable materials or coatings. The portion retained on the 4.75 mm (No. 4) sieve is known as coarse aggregate; that portion passing the 4.75 mm (No. 4) sieve is known as fine aggregate.

2.1.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements and shall be stockpiled separately.

a. Crushed Gravel: Crushed gravel shall be manufactured by crushing gravels, and shall meet all the requirements specified below.

b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.

c. Crushed Recycled Concrete: Provide crushed recycled concrete consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. The recycled material shall be free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and shall be crushed and processed to meet the required gradations for coarse aggregate. Reject recycled concrete aggregate exceeding this value. Crushed recycled concrete shall meet all other applicable requirements specified below.

d. Crushed Slag: Crushed slag shall be an air-cooled blast-furnace product having an air dry unit weight of not less than 1120 kg/cubic meter (70 pcf) as determined by ASTM C29/C29M, and shall meet all the requirements specified below.

2.1.1.1 Aggregate Base Course

ABC coarse aggregate shall not show more than 50 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131 or KS F 2508. The amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 1.

2.1.1.2 Graded-Crushed Aggregate Base Course

GCA coarse aggregate shall not show more than 50 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131 or KS F 2508. GCA coarse aggregate shall not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with ASTM C88 or KS F 2507. The amount of flat and elongated particles shall neither exceed 20 percent for the fraction retained on the 12.5 mm (1/2 inch) sieve nor 20 percent for the fraction passing the 12.5 mm (1/2 inch) sieve. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregate shall contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 1.

2.1.2 Fine Aggregate

Fine aggregates shall be angular particles of uniform density. When the fine aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements.

2.1.2.1 Aggregate Base Course

ABC fine aggregate shall consist of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.2.2 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, slag, recycled concrete, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Fine aggregate shall be produced by crushing only particles larger than

4.75 mm (No. 4) sieve in size. The fine aggregate shall contain at least 90 percent by weight of particles having two or more freshly fractured faces in the portion passing the 4.75 mm (No. 4) sieve and retained on the 2 mm (No. 10) sieve, and in the portion passing the 2 mm (No. 10) sieve and retained on the 0.425 mm (No. 40) sieve. Fine aggregate shall be manufactured from gravel particles 95 percent of which by weight are retained on the 12.5 mm (1/2 inch) sieve.

2.1.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. The aggregates shall be continuously well graded within the limits specified in TABLE 1. Sieves shall conform to ASTM E11or KS A 5101-1.

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3
50.0 mm	100	----	----
37.5 mm	70-100	100	----
25.0 mm	45-80	60-100	100
12.5 mm	30-60	30-65	40-70
4.75 mm	20-50	20-50	20-50
2.00 mm	15-40	15-40	15-40
0.425 mm	5-25	5-25	5-25
0.075 mm	0-8	0-8	0-8

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3
2 inch	100	----	----
1-1/2 inch	70-100	100	----
1 inch	45-80	60-100	100
1/2 inch	30-60	30-65	40-70
No. 4	20-50	20-50	20-50
No. 10	15-40	15-40	15-40
No. 40	5-25	5-25	5-25
No. 200	0-8	0-8	0-8

NOTE 1: Particles having diameters less than 0.02 mm (No. 635) shall not be in excess of 3 percent by weight of the total sample tested.

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, they shall be tested in accordance with ASTM C127 or KS F 2503 and ASTM C128 or KS F 2504 to determine their specific gravities. If the specific gravities vary by more than 10 percent, the percentages passing the various sieves shall be corrected as directed by the Contracting

Officer.

2.2 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the 0.425 mm (No. 40) sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC or GCA is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area. Provide line and grade stakes as necessary for control. Grade stakes shall be in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping, and excavating are the responsibility of the Contractor. Operate the aggregate sources to produce the quantity and quality of materials meeting the specified requirements in the specified time limit. Upon completion of the work, the aggregate sources on Government property shall be conditioned to drain readily and shall be left in a satisfactory condition. Aggregate sources on private lands shall be conditioned in agreement with local laws or authorities.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.4 PREPARATION OF UNDERLYING COURSE

Prior to constructing the base course(s), the underlying course or subgrade shall be cleaned of all foreign substances. At the time of construction of the base course(s), the underlying course shall contain no frozen material. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. The underlying course shall conform to Section 31 00 00 EARTHWORK, Section 32 11 16 SUBBASE COURSES. Ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses containing sands or gravels, as defined in ASTM D2487 or KS F 2324, the surface shall be stabilized prior to placement of the base course(s). Stabilization shall be accomplished by mixing ABC or GCA into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the base course is placed.

3.5 INSTALLATION

3.5.1 Mixing the Materials

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification.

3.5.2 Placing

Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 150 mm (6 inches) or less in thickness is required, place the material in a single layer. When a compacted layer in excess of 150 mm (6 inches) is required, place the material in layers of equal thickness. No layer shall be thicker than 150 mm (6 inches) or thinner than 75 mm (3 inches) when compacted. The layers shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.5.3 Grade Control

The finished and completed base course shall conform to the lines, grades, and cross sections shown. Underlying material(s) shall be excavated and prepared at sufficient depth for the required base course thickness so that the finished base course and the subsequent surface course will meet the designated grades.

3.5.4 Edges of Base Course

The base course(s) shall be placed so that the completed section will be a minimum of 600 mm (2 feet) wider, on all sides, than the next layer that will be placed above it. Additionally, place approved fill material along the outer edges of the base course in sufficient quantities to compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple layer course, allowing in each operation at least a 600 mm (2 foot) width of this material to be rolled and compacted simultaneously with rolling and compacting of each layer of base course. If this base course material is to be placed adjacent to another pavement section, then the layers for both of these sections shall be placed and compacted along this edge at the same time.

3.5.5 Compaction

Compact each layer of the base course, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified in this Section. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Alternate trips of the roller shall be slightly different lengths. Speed of the roller shall be such that displacement of the aggregate does not occur. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Continue compaction until each layer has a degree of compaction that is at least 100 percent of laboratory maximum density through the full depth of the layer. Make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.5.6 Thickness

Construct the compacted thickness of the base course as indicated. No individual layer shall be thicker than 150 mm (6 inches) nor be thinner than 75 mm (3 inches) in compacted thickness. The total compacted thickness of the base course(s) shall be within 13 mm (1/2 inch) of the thickness indicated. Where the measured thickness is more than 13 mm (1/2 inch) deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 13 mm (1/2 inch) thicker than indicated, the course shall be considered as conforming to the specified thickness requirements. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 6 mm (1/4 inch) of the thickness indicated. The total thickness of the base course shall be measured at intervals in such a manner as to ensure one measurement for each 500 square meters (yards) of base course. Measurements shall be made in 75 mm (3 inch) diameter test holes penetrating the base course.

3.5.7 Proof Rolling

Proof rolling of the areas indicated shall be in addition to the compaction specified and shall consist of the application of coverages with a heavy pneumatic-tired roller having four or more tires, each loaded to a minimum of 13,600 kg (30,000 pounds) and inflated to a minimum of 1034 kPa (125 psi). In areas designated, apply proof rolling to the top of the underlying material on which the base course is laid and to each layer of base course top of the completed ABC GCA course. Maintain water content of the underlying material at optimum or at the percentage directed from start of compaction to completion of proof rolling of that layer. Water content of each layer of the base course shall be maintained at the optimum percentage directed from start of compaction to completion of proof rolling. Any base course materials or any underlying materials that produce unsatisfactory results by proof rolling shall be removed and replaced with satisfactory materials, recompacted and proof rolled to meet these specifications.

3.5.8 Finishing

The surface of the top layer of base course shall be finished after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Thin layers of material shall not be added to the top layer of base course to meet grade. If the elevation of the top layer of base course is 13 mm (1/2 inch) or more below grade, then the top layer should be scarified to a depth of at least 75 mm (3 inches) and new material shall be blended in and compacted , compacted and proof rolled to bring to grade. Adjustments to rolling and finishing procedures shall be made as directed to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, the unsatisfactory portion shall be scarified, reworked and recompacted or it shall be replaced as directed.

3.6 SMOOTHNESS TEST

The surface of the top layer shall show no deviations in excess of 10 mm (3/8 inch) when tested with a 3.66 meter (12 foot) straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 15 meter (50 foot) intervals. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.7 TRAFFIC

Do not allow traffic on the completed base course. Completed portions of the base course may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Heavy equipment shall not be permitted except when necessary to construction, and then the area shall be protected against marring or damage to the completed work.

3.8 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter, shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

3.9 DISPOSAL OF UNSATISFACTORY MATERIALS

Any unsuitable materials that must be removed shall be disposed of outside the limits of Government-controlled land. No additional payments will be made for materials that must be replaced.

-- End of Section --

SECTION 32 11 24

GRADED CRUSHED AGGREGATE BASE COURSE FOR PERVIOUS PAVEMENT
11/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1883	(2007; E 2009; E 2009) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2217	(1985; R 1998) Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates

1.2 RELATED SECTIONS

Pervious pavement systems shall use Section 32 11 16.16 BASE COURSE FOR RIGID AND SUBBASE COURSE FOR FLEXIBLE PAVING, and Section 32 12 10 BITUMINOUS TACK AND PRIME COATS, in addition to this section.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

- Gradation
- Bearing ratio
- Liquid limit
- Plasticity index
- Percentage of wear
- Dry weight of slag
- Density
- Gradation
- Smoothness
- Density
- Thickness
- Aggregates

1.4 DELIVERY AND STORAGE

Inspect materials delivered to site for damage and store as to prevent segregation and contamination.

1.5 WEATHER LIMITATIONS

Do not construct base course when atmospheric temperature is below 2 degrees C (35 degrees F) or when rainfall or other weather conditions detrimentally affect the quality of the finished course.

1.6 CONSTRUCTION EQUIPMENT

Equipment shall be dependable and adequate for the purpose intended. Maintain equipment in satisfactory and safe operating condition. Subject to approval, special equipment dictated by local conditions may be used. Calibrated equipment, such as scales, batching equipment, spreaders, and similar items, shall have been recalibrated by an approved calibration laboratory within 12 months of commencing work.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Aggregates

Consist of durable and sound crushed concrete, crushed masonry, crushed tile, crushed gravel, crushed stone, or crushed slag, free of lumps or balls of clay or other objectionable matter. Aggregate material shall contain in total a minimum of 5 percent post-consumer recycled content, or a minimum of 20 percent post-industrial recycled content. Crushed stone and gravel shall be free from flat, elongated, soft, or disintegrated pieces. Crushed gravel retained on a 4.75 mm (No. 4) sieve shall have at least 90 percent by weight with at least two fractured faces and 100 percent by weight with at least one fractured face. Base course materials samples shall have a bearing ratio of at least 100 as determined by laboratory tests on a 4-day soaked specimen in accordance with ASTM D1883; compact specimen in accordance with ASTM D1557, Method D. Determine grain size in accordance with ASTM C136 and amount of material finer than 75 micrometers (200 mesh) sieve in accordance with ASTM C117. Aggregate, other than slag, shall have a percentage of wear not exceeding 40 when tested in accordance with ASTM C131, Grading A. Slag shall be an air-cooled, blast furnace product having a dry weight of not less than 1120 kilograms per cubic meters (70 pounds per cubic foot) when tested in accordance with ASTM C29/C29M and shall consist of angular fragments uniform in density and quality, reasonably free from thin, elongated pieces, dirt, or other objectionable material. Soil binder material, that portion of material passing the 425 micrometers (No. 40) sieve, shall be of such composition that the composite material conforms to the requirements specified herein. The base course shall be of such nature that it can be compacted readily with watering and rolling to a firm, stable base and shall conform to one of the following sizes:

Percentage by Weight Passing Square Mesh Laboratory Sieves			
Sieves	Size Numbers		
	1	2	3
50.0 mm (2 inch)	100	-	-
37.5 mm (1 1/2 inch)	70-100	100	-
25.0 mm (1 inch)	45-80	60-100	100
12.5 mm (1/2 inch)	30-60	30-65	40-70
4.75 mm (No. 4)	20-50	20-50	20-50
2.0 mm (No. 10)	15-40	15-40	15-40
425 micrometers (No. 40)	5-25	5-25	5-25
75 micrometers (No. 200)	0-10	0-10	0-10

That portion of the material passing the 425 micrometers (No. 40) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 5 as determined by ASTM D4318. Prepare samples in accordance with ASTM D2217, Procedure A.

2.1.2 Pervious Base Course

Base aggregate for pervious pavement systems shall consist of aggregate as specified in paragraph Aggregates except as specified below. Material passing the 75 micrometers (No. 200) sieve is not permitted. Unevenly graded screenings and stone dust are not permitted.

2.1.2.1 Asphalt-Treated Permeable Base

Asphalt binder shall be steam-refined asphalt, grade AR-8000. "Popcorn mix" aggregate shall conform to the following grading:

Percentage by Weight Passing Square Mesh Laboratory Sieves	
Sieves	Percent Passing
25.0 mm (1 inch)	100
19.0 mm (3/4 inch)	90-100
12.5 mm (1/2 inch)	35-65
9.0 mm (3/8 inch)	20-45
4.75 mm (No. 4)	0-10
2.4 mm (No. 8)	0-5

2.1.2.2 Cement-Treated Permeable Base

Portland cement binder shall be Type II Modified. Pozzolan shall not be substituted for portland cement. Aggregate shall conform to the 25 mm by 4.75 mm (1 inch by No. 4) primary nominal coarse aggregate grading, with 52 to 85 percent by weight passing through a 19 mm (3/4 inch) sieve.

PART 3 EXECUTION

3.1 BASE COURSE

Construct the graded aggregate base course on a prepared subgrade previously constructed subbase course, as indicated. Verify compacted subgrade, granular base, or stabilized soil is acceptable and ready to support paving and imposed loads. Provide line and grade stakes for control. Place grade stakes in lanes parallel to the centerline of areas to be paved and space for string lining or other control methods. The base course shall consist of aggregate processed, deposited, spread, and compacted on a prepared surface. The Contractor shall be responsible for protection of completed areas against detrimental effects. Recondition, reshape, and recompact areas damaged by freezing, rainfall, or other weather conditions.

3.2 OPENING AND OPERATION OF PITS

Perform stripping, clearing, processing, and blending in the opening of new pits and operation of existing pits as necessary to obtain acceptable material. Open pits in a manner to expose the vertical faces of the deposits for suitable working depths, following which the material shall be obtained in successive vertical cuts extending through the exposed strata. Waste strata and pockets of unsuitable materials overlaying or occurring in the deposit. Change or modify the method of operating the pits, and the processing and blending of the material when necessary to obtain material conforming to the specified requirements. Upon completion of the work, condition pits to drain readily and leave in a satisfactory condition.

3.3 MIXING OF MATERIALS

Mix aggregates in a stationary or traveling plant. Proportion aggregates by weight or volume in such quantities that specified gradation, liquid limit, and plasticity index requirements are met after the base course has been placed and compacted. Incorporate, during the mixing operation, water in quantities sufficient to provide the necessary moisture content for the specified compaction. Mixing operations shall produce satisfactory uniform blending and the method of discharging into trucks shall not produce segregation.

3.4 PLACING

Do not dump mixed materials in piles, but place on prepared subgrade or subbase in layers of uniform thickness with a spreader. When a compacted course 150 mm (6 inches) in thickness is required, place material in a single layer. When a compacted course in excess of 150 mm (6 inches) is required, place material in layers of equal thickness. Do not exceed 150 mm (6 inches) or have less than 75 mm (3 inches) in thickness for any compacted layer. Place layers so that when compacted, they will be true to grades or levels required with the least possible surface disturbance. Where the base course is constructed in more than one layer, clean previously constructed layers of loose and foreign matter. Maintain material water content during the placing period to obtain the compaction specified. Make adjustments in placing procedures or equipment to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to insure a satisfactory base course.

3.4.1 Stationary-Plant Method

Mix aggregates, binder material and water until a uniform homogeneous mixture is obtained. Do not dump materials in piles; place in layers of essentially uniform thickness, not to exceed 150 mm (6 inches) after compaction, by an approved spreader. Tail gate spreading will be acceptable only with permission, under conditions such as where space limitations prohibit use of the spreader.

3.4.2 Windrow Traveling-Plant Method

Place aggregates and binder materials in windrows of such cross section and proportions that, when picked up, mixed, and redeposited in windrows, the finished mixture shall conform to the specified requirements. Do not exceed the rated capacity of the traveling plant with the size of the windrow of the combined materials. Add water, in quantity sufficient to provide the necessary moisture content for compacting, to the aggregates at the time of mixing. Mix materials uniformly by the traveling plant, deposit in windrows of uniform cross section, and spread in a layer of uniform thickness to the required contour and grades.

3.5 COMPACTING AND FINISHING

Immediately following the placing, spread the finished mixture uniformly in a layer and bring to optimum moisture content. The loose thickness and the surface of the layer shall be such that the specified density and the required thickness shall be obtained after compaction. Compact the layer with steel-faced, vibrating or pneumatic-tired rollers, or other suitable compacting equipment or combinations thereof. Continue compacting until the layer is compacted through the full depth to a field density of at least 100 percent of the maximum density at optimum moisture content tested in accordance with ASTM D1556 or ASTM D6938 . In areas not accessible to rollers or compactors, compact the mixture with mechanical hand tampers. If the mixture is excessively moistened by rain, aerate by blade graders, or other suitable equipment. Aerate until the moisture content of the material is that needed to obtain the required density. Finish the surface of the layer by a combination of rolling and blading. Final surface shall be smooth and free from waves, irregularities, and ruts or soft yielding spots.

3.6 PROOF ROLLING

On the center 7.50 m (25 feet) of taxiways and on the center 30 m (100 feet) of runways, in addition to compacting the base course to the required density, proof roll the top surface of the completed base course by making eight coverages with a heavy rubber-tired roller having four tires with each tire loaded to 13,600 kg (30,000 pounds) or more and inflated to at least 1034 kPa (150 psi). Make four coverages over other areas to be paved, excluding the runway over-runs, blast protection areas, and shoulders. A coverage is defined as one application of one tire print over each point in the surface of the designated area. When under the action of the proof rolling, the base course yields, pumps, or otherwise fails, remove, replace with suitable materials, and recompact materials in the base course or in the underlying layers indicated to be unsatisfactory. The speed of the roller shall not exceed 8 kph (5 miles per hour). Obtain approval upon completion of the proof rolling of the base course.

3.7 FINISHING AT EDGES OF BASE COURSE

Place earth or other approved materials along the edges of the base course in such quantity that it will compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, place material to the thickness of each layer. In each operation, allow at least a 300 mm (one foot) width of the shoulder to be rolled and compacted simultaneously with the rolling and compacting of each layer.

3.8 FIELD QUALITY CONTROL

Approve materials and material sources in advance of the use of such materials in the work. Replace base where samples are removed. Take duplicate samples at the same time and in the same manner as the original.

3.8.1 Sampling

3.8.1.1 Aggregates at the Source

Prior to production and delivery of aggregates, take at least one initial sample in accordance with ASTM D75/D75M. Collect each sample by taking three incremental samples at random from the source material to make a composite sample of not less than 23 kg (50 pounds). Repeat above sampling when source of material is changed or when unacceptable deficiencies or variations from specified grading of materials are found in testing.

3.8.1.2 During Construction

Take one random sample from each 1000 metric tons (1000 tons) of completed course material, but not less than one random sample per day's run. Take samples in accordance with ASTM D75/D75M.

3.8.1.3 Sample Identification

Place each sample in a clean container, securely fastened to prevent loss of material. Tag each sample for identification and with the following information:

Contract No.______________________________________
Sample No.______________________ Quality ___________
Date of Sample_____________________________________
Sampler____
Source____
Intended Use______________________________________
For Testing_______________________________________

3.8.2 Testing

3.8.2.1 Aggregates

Test each sample of base course material without delay. Make gradation tests from each sample in accordance with ASTM C136. Make sieve analysis on material passing the 75 micrometers (No. 200) sieve in accordance with ASTM C117.

3.8.2.2 Smoothness Tests

Test with a 3 m (10 foot) straightedge, applied parallel with and at right angles to the center line of the paved area. Correct deviations in the surface in excess of 10 mm (3/8 inch) by loosening, adding or removing material, reshaping, watering, and compacting. The smoothness requirements specified herein apply only to the top layer when base course is constructed in more than one layer.

3.8.2.3 Field Density Tests

ASTM D1556 or ASTM D6938. Take one test for each 420 square meters (500 square yards) of each layer of base course.

3.8.2.4 Laboratory Density Tests

In accordance with ASTM D1557, Method D.

3.8.2.5 Thickness Tests

Measure thickness of base course at intervals such that there will be a depth measurement for at least each 420 square meters (500 square yards) of complete base course. Make depth measurements by test holes, at least 75 mm (3 inches) in diameter, through the base course. Where base course deficiency is more than 13 mm (1/2 inch), correct by scarifying, adding mixture of proper gradation, reblading, and recompacting. Where the measured thickness is more than 13 mm (1/2 inch) thicker than indicated, consider it as the indicated thickness plus 13 mm (1/2 inch) for determining the average. The average thickness is the average of the depth measurements and shall not under run the thickness indicated.

3.9 MAINTENANCE

After construction is completed, maintain the base course throughout, except where portion of the succeeding course is under construction thereon. Maintenance includes drainage, rolling, shaping, and watering, as necessary, to maintain the course in proper condition. Correct deficiencies in thickness, composition, construction, smoothness, and density, which develop during the maintenance, to conform to the requirements specified herein. Maintain sufficient moisture by light sprinkling with water at the surface to prevent a dusty condition.

-- End of Section --

SECTION 32 12 10

BITUMINOUS TACK AND PRIME COATS
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 20	(1970; R 2004) Penetration-Graded Asphalt Cement
AASHTO M 226	(1980; R 2008) Standard Specification for Viscosity-Graded Asphalt Cement
AASHTO M 81	(1992; R 2008) Standard Specification for Cutback Asphalt (Rapid-Curing Type)
AASHTO M 82	(1975; R 2008) Standard Specification for Cutback Asphalt (Medium-Curing Type)
AASHTO T 102	(2009) Standard Method of Test for Spot Test of Asphaltic Materials
AASHTO T 40	(2002; R 2006) Sampling Bituminous Materials

ASTM INTERNATIONAL (ASTM)

ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2026/D2026M	(1997; R 2010e1) Cutback Asphalt (Slow-Curing Type)
ASTM D2027	(2010) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2010) Cutback Asphalt (Rapid-Curing Type)
ASTM D2397	(2005) Standard Specification for Cationic Emulsified Asphalt
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction

ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D977	(2012) Emulsified Asphalt

KOREAN INDUSTRIAL STANDARDS (KS)

KS M 2202	(2004) Cutback Asphalt
KS M 2203	(2008) Emulsified Asphalt
KS M 2208	(2007) Viscosity-Graded asphalt cement for use pavement construction

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Plant, equipment, machines and tools used in the work are subject to approval and shall be maintained in a satisfactory working condition at all times. Calibrated equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment, should have been recalibrated by a calibration laboratory within 12 months prior to commencing work .

1.2.2 Bituminous Distributor

Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 295 kg/25 mm (650 psi) of tire width to prevent rutting, shoving or otherwise damaging the base surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.23 to 9.05 L/square meter (0.05 to 2.0 gallons per square yard), with a pressure range of 172.4 to 517.1 kPa (25 to 75 psi) and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process.

1.2.3 Heating Equipment for Storage Tanks

The equipment for heating the bituminous material shall be steam, electric, or hot oil heaters. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot get into the material. Fix an armored thermometer to the tank with a temperature range from 4.4 to 204.4 degrees C (40 to 400 degrees F) so that the temperature of the bituminous material may be determined at all times.

1.2.4 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Sampling and Testing

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.5 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. Apply bituminous coat only when the atmospheric temperature in the shade is 10 degrees C (50 degrees F) or above and when the temperature has not been below 2 degrees C (35 degrees F) for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PRIME COAT

Provide asphalt conforming to AASHTO M 81 AASHTO M 82, Grade RC-70, MC-30, MC-70 and specified in the following two subparagraphs.

2.1.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2026/D2026M, Grade SC-70 ASTM D2027, Grade MC-30 MC-70 ASTM D2028/D2028M, Grade RC-70 or KS M 2202, MC-0, MC-1.

2.1.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 or SS1h or ASTM D2397, Type CSS-1 or CSS-1h.

2.2 TACK COAT

Provide asphalt conforming to ASTM D2028/D2028M, ASTM D946/D946M, ASTM D3381/D3381M, ASTM D977 ASTM D2397, AASHTO M 81, AASHTO M 20, AASHTO M 226 or KS M 2208, KS M 2202, and KS M 2203, Grade RC-70, as indicated.

2.2.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2026/D2026M, Grade SC-70, ASTM D2027, Grade MC-30 or MC-70, or ASTM D2028/D2028M, Grade RC-70.

2.2.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 or SS1h, ASTM D2397, Type CSS-1 or CSS-1h, or KS M 2203, Type RS(C)-4 or RS(A)-4. Dilute the emulsified asphalt with equal parts of water. The base asphalt used to manufacture the emulsion shall show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. The surface shall be dry and clean at the time of treatment.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities between 0.20 L/square meter (0.05 gallon per square yard) and 0.70 L/square meter (0.15 gallon per square yard) of pavement surface.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.80 L (0.18 gallon) nor more than 1.60 L/square meter (0.35 gallon per square yard) of pavement surface.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Asphalt application temperature shall provide an application viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 square mm/sec (20 and 120 centistokes), kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

Liquid Asphalts	
SC-250	75-132 degrees C
MC-30	29-87 degrees C
MC-70	50-107 degrees C
MC-250	75-132 degrees C
RC-70	50-90 degrees C*
RC-250	75-12 degrees C*

Paving Grade Asphalts

Penetration Grades

200-300	plus 130 degrees C
120-150	plus 132 degrees C
85-100	plus 137 degrees C

Viscosity Grades

AC 2.5	plus 132 degrees C
AC 5	plus 137 degrees C
AC 10	plus 137 degrees C
AR 1000	plus 135 degrees C
AR 2000	plus 140 degrees C
AR 4000	plus 143 degrees C

Emulsions

RS-1	20-60 degrees C
MS-1	20-70 degrees C
HFMS-1	20-70 degrees C
SS-1	20-70 degrees C
SS-1h	20-70 degrees C
CRS-1	52-85 degrees C
CSS-1	20-70 degrees C
CSS-1h	20-70 degrees C

Liquid Asphalts

SC-70	120-225 degrees F
SC-250	165-270 degrees F
MC-30	85-190 degrees F
MC-70	120-225 degrees F
MC-250	165-270 degrees F
RC-70	120-200 degrees F*
RC-250	165-250 degrees F*

Paving Grade Asphalts

Penetration Grades

200-300	plus 265 degrees F
120-150	plus 270 degrees F
85-100	plus 280 degrees F

Viscosity Grades

AC 2.5	plus 270 degrees F
AC 5	plus 280 degrees F

AC 10	plus 280 degrees F
AR 1000	plus 275 degrees F
AR 2000	plus 285 degrees F
AR 4000	plus 290 degrees F
Emulsions	
RS-1	70-140 degrees F
MS-1	70-160 degrees F
HFMS-1	70-160 degrees F
SS-1	70-160 degrees F
SS-1h	70-160 degrees F
CRS-1	125-185 degrees F
CSS-1	70-160 degrees F
CSS-1h	70-160 degrees F

These temperature ranges exceed the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the Bituminous Distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots missed by the distributor with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 8 meters (25 feet) of heating, distributing, and transferring operations of bituminous material other than bituminous emulsions. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat shall conform to all requirements as described herein.

3.4.2 Prime Coat

Apply a prime coat at locations shown on the Drawings. The prime coat is required if it will be at least 7 days before the surfacing (Asphalt cement hot mix concrete) layer is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Government. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 172.4 to 517.1 kPa (25 to 75 psi); the rate shall be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings. Apply the tack coat when the surface to be treated is dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor with the bituminous material. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of pavement, allow the bituminous coat to cure and to obtain evaporation of any volatiles or moisture. Maintain the coated surface until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up and cure excess bituminous material.

3.6 FIELD QUALITY CONTROL

Samples of the bituminous material shall be tested for compliance with the applicable specified requirements. A sample shall be obtained and tested by the Contractor for every 375 liters (100 gallons) of bituminous material used, or one sample per day, whichever is more.

3.7 SAMPLING AND TESTING

Submit copies of all test results for emulsified asphalt, and bituminous materials, within 24 hours of completion of tests. Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt, compliance with applicable specified requirements, not less than 30 days before the material is required in the work. Perform sampling and testing by an approved commercial testing laboratory or by facilities furnished by the Contractor.

3.7.1 Sampling

The samples of bituminous material, unless otherwise specified, shall be in accordance with ASTM D140/D140M or AASHTO T 40. Sources from which bituminous materials are to be obtained shall be selected and notification furnished the Contracting Officer within 15 days after the award of the contract.

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibration shall be made with the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with ASTM D2995.

3.7.3 Trial Applications

Before providing the complete bituminous coat, apply three lengths of at least 30 meters (100 feet) for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of 0.20 L/square meter (0.05 gallons per square yard). Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 1.10 L/square meter (0.25 gallon per square yard). Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --

SECTION 32 12 11

BITUMINOUS SURFACE TREATMENT
11/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D1139/D1139M	(2009) Aggregate for Single or Multiple Bituminous Surface Treatments
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2028/D2028M	(2010) Cutback Asphalt (Rapid-Curing Type)
ASTM D2397	(2005) Standard Specification for Cationic Emulsified Asphalt
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3625	(1996; R 2005) Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D977	(2012) Emulsified Asphalt

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2501	(2007) Sampling Aggregate
KS F 2507	(2007) Method of test for soundness of aggregates by use of sodium sulfate
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine
KS M 2201	(2007) Straight Asphalt
KS M 2202	(2004) Cutback Asphalt
KS M 2203	(2008) Emulsified Asphalt
KS M 2208	(2007) Viscosity-Graded asphalt cement for use pavement construction

1.2 SYSTEM DESCRIPTION

Provide equipment dependable and adequate for the purpose intended and properly maintained in satisfactory and safe operating condition at all times. Discontinue the use of equipment which fails to produce satisfactory work and replace with satisfactory equipment. Calibrated equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment, shall have been recalibrated by an approved calibration laboratory within 6 months prior to commencing work .

1.2.1 Bituminous Distributors

The distributors shall have pneumatic tires of such width and number that the load produced on the base surface does not exceed 11.6 kg per mm (650 pounds per inch) of tire width. Distributors shall be designed and equipped to distribute bituminous material uniformly at even heat on various widths of surface at readily determined and controlled rates ranging from 0.20 to 9.1 L/square meter (0.05 to 2.00 gallons/square yard), with a pressure range of 172 to 517 kPa (25 to 75 psi). The allowable variation from any specified rate shall not exceed 5 percent. Distributor equipment shall include a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, a thermometer for reading the temperature of tank contents, and a hose attachment suitable for applying bituminous material to areas not accessible with distributor spray bar. The distributor shall be equipped for circulation and agitation of bituminous material during the heating process.

1.2.2 Single-Pass, Surface-Treatment Machines

The machines shall be capable of spraying bituminous material and spreading aggregate in one pass. Bituminous spraying equipment shall conform to the requirements given above for a bituminous distributor. The machine shall be capable of spreading aggregates at controlled amounts per square yard as specified. In addition, the single-pass, surface-treatment machine shall be capable of placing a surface treatment adjacent to an existing surface treatment, forming a joint of the same thickness and uniformity as other portions of the surface treatment. Ridges or blank spaces will not be permitted. Joints in the second application shall be formed at least 300 mm (1 foot) from those formed in the first application.

1.2.3 Heating Equipment for Storage Tanks

The equipment shall consist of coils and equipment for producing steam or hot oil and be designed to prevent the introduction of steam or hot oil into the material. An armored thermometer with a range of 35 to 200 degrees C (100 to 400 degrees F) shall be affixed to the tank so the temperature of the bituminous material may be determined at all times.

1.2.4 Power Rollers

Power rollers shall be steel-wheeled or pneumatic-tired type, conforming to the following requirements:

a. Steel-wheeled rollers shall have at least one steel drum and weigh a minimum of 4 metric tons (5 tons). Steel wheels of the rollers shall be equipped with adjustable scrapers.

b. Pneumatic-tired rollers shall be self-propelled and have wheels mounted on two axles in such manner that the rear tires will not follow in the tracks of the forward group. Tires shall be uniformly inflated to pressure between 414 kPa (60 psi) and 552 kPa (80 psi). The pneumatic-tired rollers shall be equipped with boxes or platforms for ballast loading and shall be loaded so that the tire print width of each wheel is not less than the clear distance between tire prints.

1.2.5 Mechanical Spreaders

The spreaders shall be adjustable and capable of spreading aggregate at controlled amounts per square yard, as specified.

1.2.6 Brooms and Blowers

The machines shall be of the power type, capable of cleaning surfaces to be treated.

1.2.7 Scales

The scales shall be standard truck scales of the beam type equipped with a weight-recording device. The scales shall be sufficient in size and capacity to accommodate the trucks used in hauling aggregates. The scales shall be tested by the Contractor in the presence of the Contracting Officer. Keep the necessary number of standard weights on hand, at all times, for testing the scales.

1.2.8 Weigh house

Provide a weatherproof weigh house constructed in a manner to afford adequate protection for the indicating and recording devices of the scales.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cutback Asphalt
Asphalt Cement

SD-06 Test Reports

Aggregate Gradation Tests
Wear Test
Soundness Test
Stripping Test

1.4 QUALITY ASSURANCE

1.4.1 Safety Precautions

No smoking, or open flames shall be permitted within 8 m (25 feet)of heating, distributing, or transferring operations of bituminous materials other than bituminous emulsions. When tar is used, a full-face, organic, vapor-type respirator and protective creams shall be used by personnel exposed to fumes. Protective creams shall not substitute for cover clothing.

1.4.2 Sampling and Testing

Sampling and testing is the responsibility of the Contractor. Sampling and testing shall be performed by an approved commercial testing laboratory, or by the Contractor, subject to approval. Sampling shall be in accordance with ASTM D75/D75M or KS F 2501 for aggregates and ASTM D140/D140M for bituminous material, unless otherwise directed. Perform aggregate gradation tests on each sample in accordance with ASTM C136. Perform all other aggregate tests on the initial source samples and repeat tests when there is a change of source. Perform sieve analyses daily from material samples. The tests shall include an analysis of each gradation of material. Perform tests in sufficient number to ensure that materials meet specified requirements. Submit copies of test results, within 24 hours after completion of each test.

1.4.3 Wear Test

Perform the wear test in accordance with ASTM C131 or KS F 2508 to ensure that aggregates have a percentage of wear not exceeding 40 percent after 500 revolutions. Submit copy of most recent test result for aggregates in stockpiles or at the source to be used for current project or contract.

1.4.4 Soundness Test

Perform the soundness test as specified by ASTM C88 or KS F 2507 to ensure that aggregates have a weight loss not greater than 12 percent when subjected to five cycles of the magnesium sulfate test. Submit copy of most recent test result for aggregates in stockpiles or at the source to be used for current project or contract.

1.4.5 Stripping Test

Perform stripping tests meeting the requirements of ASTM D3625. Deleterious substances shall not exceed the limits of ASTM D1139/D1139M.

Submit copy of most recent test result for aggregates in stockpiles or at the source to be used for current project or contract.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling. Store aggregates preventing segregation and contamination.

1.6 ENVIRONMENTAL REQUIREMENTS

Apply bituminous surface treatment only when the existing surface or base course is dry or contains moisture not in excess of the amount that will permit uniform distribution and the desired adhesion. Bituminous surface treatment shall not be applied when either the atmospheric temperature, in the shade, is below 10 degrees C (50 degrees F) or the pavement surface to be treated is below 20 degrees C (70 degrees F) unless otherwise directed.

PART 2 PRODUCTS

2.1 MATERIALS

Use mineral aggregate and bituminous material of the following types, gradations, grades, and consistencies that meet the requirements of stripping, wear, and soundness tests as specified in paragraph SAMPLING AND TESTING.

2.1.1 Mineral Aggregate

Provide aggregate consisting of crushed stone, crushed gravel, or crushed slag of such nature that thorough coating of bituminous material, used in the work, will not strip off upon contact with water. Moisture content of the aggregate shall be such that the aggregate will be readily coated with the bituminous material. Drying may be required, as directed. Aggregate shall conform to the gradation shown below. Determine gradation of the aggregates by ASTM C136.

AGGREGATE GRADATION
SINGLE BITUMINOUS SURFACE TREATMENT
(PERCENT BY WEIGHT PASSING)

Sieve Designation	No. 1	No. 2	No. 3
25.0 mm	100	--	--
19.0 mm	90-100	100	--
12.5 mm	20-55	90-100	100
9.5 mm	0-15	40-70	85-100
4.75 mm	0-5	0-15	10-30
2.36 mm	--	0-5	0-10
1.18 mm	--	--	0-5

AGGREGATE GRADATION
SINGLE BITUMINOUS SURFACE TREATMENT
(PERCENT BY WEIGHT PASSING)

Sieve Designation	No. 1	No. 2	No. 3
1 inch	100	--	--
3/4 inch	90-100	100	--
1/2 inch	20-55	90-100	100
3/8 inch	0-15	40-70	85-100
No. 4	0-5	0-15	10-30
No. 8	--	0-5	0-10
No. 16	--	--	0-5

AGGREGATE GRADATION
DOUBLE BITUMINOUS SURFACE TREATMENT
(PERCENT BY WEIGHT PASSING)

Sieve Designation	No. 1	No. 2	No. 3	No. 4
25.0 mm	100	--	--	--
19.0 mm	90-100	--	100	--
12.5 mm	20-55	100	90-100	--
9.5 mm	0-15	85-100	40-70	100
4.75 mm	0-5	10-30	0-15	85-100
2.36 mm	--	0-10	0-5	10-40
1.18 mm	--	0-5	--	0-10
0.30 mm	--	--	--	0-5

AGGREGATE GRADATION
DOUBLE BITUMINOUS SURFACE TREATMENT
(PERCENT BY WEIGHT PASSING)

Sieve Designation	No. 1	No. 2	No. 3	No. 4
1 inch	100	--	--	--
3/4 inch	90-100	--	100	--
1/2 inch	20-55	100	90-100	--
3/8 inch	0-15	85-100	40-70	100
No. 4	0-5	10-30	0-15	85-100
No. 8	--	0-10	0-5	10-40
No. 16	--	0-5	--	0-10
No. 50	--	--	--	0-5

2.1.1.1 Crushed Stone

Provide crushed stone consisting of clean, sound, durable particles, free of soft or disintegrated pieces, dust, or foreign matter.

2.1.1.2 Crushed Gravel

Provide crushed gravel consisting of clean, sound, durable particles, free of soft or disintegrated pieces or foreign matter. At least 90 percent by weight of the particles shall have at least two fractured faces.

2.1.1.3 Crushed Slag

Provide crushed slag which is an air-cooled blast-furnace product having a dry weight of not less than 1120 kg/cubic meter (70 pcf), and consists of angular particles uniform in density and quality and free of dust and foreign matter. Determine the weight of a cubic meter (foot) of slag aggregate by ASTM C29/C29M.

2.1.1.4 Aggregate Quantities

The bituminous material and aggregate shall be spread within the quantity limits shown below. The individual quantities of bituminous material and aggregate may be varied to meet specific field conditions at all times during progress of the work, as directed, without adjustments to contract unit prices. Aggregate weights shown are for aggregates having a specific gravity of 2.65. If the specific gravity of the aggregate used is other than 2.65, appropriate adjustments shall be made in number of kg (pounds) required to ensure a constant volume of aggregate per square meter (yard) of treatment.

QUANTITIES (PER SQUARE METER
FOR SINGLE SURFACE TREATMENT

Gradation No.	Bituminous Material (Liter)	Aggregate (Kilograms)
1	1.36-2.04	19-27
2	0.68-1.36	11-19
3	0.45-0.91	8-14

QUANTITIES (PER SQUARE YARD
FOR SINGLE SURFACE TREATMENT

Gradation No.	Bituminous Material (Gallons)	Aggregate (Pounds)
1	0.30-0.45	35-50
2	0.15-0.30	20-35
3	0.10-0.20	15-25

QUANTITIES (PER SQUARE METER)
FOR DOUBLE SURFACE TREATMENT

Gradation No.	Bituminous Material (Liters) First Application	Aggregate (Kilograms) First Spreading	Bituminous Material (Liters) Second Application	Aggregate (Kilograms) Second Application
1	0.91-1.36	15-18	--	--
2	--	--	0.91-1.36	11-14
3	0.68-0.91	11-14	--	--
4	--	--	0.68-0.91	5-8

QUANTITIES (PER SQUARE YARD)
FOR DOUBLE SURFACE TREATMENT

Gradation No.	Bituminous Material (Gallons) First Application	Aggregate (Pounds) First Spreading	Bituminous Material (Gallons) Second Application	Aggregate (Pounds) Second Application
1	0.20-0.30	28-34	--	--
2	--	--	0.20-0.30	20-25
3	0.15-0.20	20-25	--	--
4	--	--	0.15-0.20	10-15

2.1.2 Bituminous Materials

2.1.2.1 Cutback Asphalt

Rapid curing cutback asphalt shall conform to ASTM D2028/D2028M, Designation RC-250 or KS M 2202 Class RC-3. Submit temperature-viscosity relationship of cutback asphalt.

2.1.2.2 Emulsified Asphalt

Rapid-setting emulsified asphalt shall conform to ASTM D977, Grade RS-1 or RS-2 or ASTM D2397, Grade CRS-1 or CRS-2 or KS M 2203 Class RS(A)-1, RS(A)-2, RS(C)-1 or RS(C)-2.

2.1.2.3 Asphalt Cement

Asphalt cement shall conform to ASTM D946/D946M, Penetration Grade 200-300; or KS M 2201 Penetration Grade 200-300; or ASTM D3381/D3381M, Viscosity Grade AC-2.5 AC-5AC-10 AC-20 AR2000 or KS M 2208 Viscosity Grade AC-2.5, AC-5, AC-10, AC-20, AR-2000. Submit temperature-viscosity relationship of asphalt cement.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Immediately before applying the first course of bituminous material, clean the surface of loose material with power brooms or power blowers. Take care to remove all dirt, clay, and other loose or foreign matter. Flush the surface with water, when necessary to achieve a clean surface, only when directed by the Contracting Officer; allow the surface to dry after flushing.

3.2 APPLICATION OF FIRST COURSE

3.2.1 Bituminous Material

Apply bituminous material by means of a bituminous distributor at the temperature specified in paragraph APPLICATION TEMPERATURE OF MATERIALS, below or as directed; and within the limits specified in paragraph QUANTITY LIMITS in PART 1. Apply bituminous material in such a manner that uniform distribution is obtained over all surfaces treated. Unless the distributor is equipped to obtain a satisfactory result at the junction of previous and subsequent applications, building paper shall be spread on the surface for a sufficient distance back from the ends of each application so that flow through the sprays may be started and stopped on the paper in order that all sprays will operate at full force on the surface treated. Immediately after application, remove and destroy the building paper. Areas inaccessible to the distributor shall be properly treated with bituminous material using the hose attachment. Protect adjacent buildings, structures, and trees to prevent their being spattered or marred.

3.2.2 Spreading of Aggregate

Immediately following application of bituminous material, spread aggregate uniformly over the surface within the limits of the quantities specified in paragraph QUANTITY LIMITS in PART 1. Spreading shall be done with mechanical spreaders. Spread aggregate evenly by hand on all areas missed by the mechanical spreader. Equipment spreading aggregate shall be operated backwards, so that the bituminous material will be covered ahead of the truck wheels. When hand spreading is employed on inaccessible areas, spread aggregate directly from trucks. Additional aggregate shall be spread by hand over areas having insufficient cover, and spreading shall continue during these operations when necessary.

3.2.3 Brooming and Rolling

Roll the surface with a pneumatic-tired and a steel-wheeled roller after sufficient aggregate is spread. Continue rolling until no more aggregate can be worked into the treated surface. The use of the steel-wheeled roller will be discontinued, or a lighter weight steel wheel roller substituted, as directed, if the roller being used causes excessive crushing and shattering of the aggregate. If the aggregate is not distributed properly, broom the surface as soon as possible after the first coverage by the roller, but not until the surface has set sufficiently to prevent excessive marking. Brooming, rolling, and supplemental spreading of aggregate shall continue until the surface is cured and rolled sufficiently to key and set the aggregate. In places not accessible to rollers, compact the aggregate with pneumatic tampers. Aggregate that becomes contaminated with foreign matter shall be removed, replaced with clean aggregate, and rerolled, as directed. Maintain and protect the treated areas by use of barricades for a period not to exceed 30 days.

3.3 APPLICATION OF SECOND COURSE

3.3.1 Bituminous Treatment

Apply the bituminous material for the second course within 48 hours after construction of the first course, weather permitting. Remove excess aggregate prior to the second application of bituminous material. If the treated surface is excessively moistened by rain, allow the surface to dry for such time as deemed necessary. Perform the second application of bituminous material in the manner specified in paragraph APPLICATION OF FIRST COURSE, including temperature and QUANTITY LIMITS.

3.3.2 Aggregate

Immediately following the second application of bitumen, aggregate conforming to the gradation and limits specified in paragraph QUANTITY LIMITS shall be spread uniformly over the bituminous material and processed in the manner specified for the first course.

3.3.3 Brooming and Rolling Second Course

The surface shall be rolled and broomed in the manner specified for the first course until a thoroughly bonded, smooth, even-textured surface is produced. Sweep off the surface surplus aggregate and remove it prior to final acceptance.

3.4 APPLICATION TEMPERATURE OF MATERIALS

3.4.1 Cutback Asphalt

Use Saybolt Furol as necessary to provide an application viscosity between 0.00004 and 0.00012 square meter per second (40 and 120 centistokes, kinematic or 20 and 60 seconds).

3.4.2 Emulsified Asphalt

Within the following ranges:

RS-1: 21.1-60 degrees C (70-140 degrees F).

RS-2, CRS-1 and CSR-2: 51.7-85 degrees C (125-185 degrees F).

3.4.3 Asphalt Cement

Use Saybolt Furol as necessary to provide an application viscosity between 0.00004 and 0.00012 square meter per second (40 and 120 centistokes, kinematic or 20 and 60 seconds).

3.5 TRIAL APPLICATION

Preliminary to providing a complete surface treatment, treat three lengths of at least 30.5 m (100 feet) each for the full width of the distributor bar. Use the appropriate typical application rates specified herein for one surface treatment trial. Make other surface treatment trials using various amounts of materials as may be deemed necessary.

3.6 PROTECTION

Keep all traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces. Protect the treated areas from traffic for at least 24 hours after final application of bituminous material and aggregate, or for such time as necessary to prevent picking up. Immediately prior to opening to traffic, roll the entire treated area with a self-propelled pneumatic-tired roller.

-- End of Section --

SECTION 32 12 15.13

HOT-MIX ASPHALT AIRFIELD PAVING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 156	(2013) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO T 308	(2010) Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO T 329	(2013) Standard Test Method for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

ASPHALT INSTITUTE (AI)

AI MS-2	(1997 6th Ed) Mix Design Methods

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C1252	(2006) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D1461	(2011) Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D2172/D2172M	(2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2419	(2009) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D242/D242M	(2009) Mineral Filler for Bituminous Paving Mixtures
ASTM D2489/D2489M	(2008) Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D2726/D2726M	(2013) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3665	(2012) Random Sampling of Construction Materials
ASTM D3666	(2013) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009) Effect of Moisture on Asphalt

	Concrete Paving Mixtures
ASTM D5444	(2008) Mechanical Size Analysis of Extracted Aggregate
ASTM D6307	(2010) Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D6926	(2010) Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus
ASTM D6927	(2006) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D979/D979M	(2012) Sampling Bituminous Paving Mixtures
ASTM E1274	(2003; R 2012) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2309	(2009) Standard test method for amount of material in passing standard sieve 0.075mm in soils
KS F 2340	(2009) Standard test method for sand equivalent value of soils and fine aggregate
KS F 2353	(2010) Testing method for bulk specific gravity and density of compacted bituminous mixtures using paraffin-coated specimens
KS F 2352	(2005) Testing method for effect of water on cohesion of compacted asphalt mixtures
KS F 2354	(2013) Testing method for bitumen content from bituminous paving mixtures
KS F 2356	(2013) Requirements of mixing plants for hot mix asphalt
KS F 2360	(2006) Testing Method for Degree of Particles Coating of Asphalt -aggregate Mixture
KS F 2384	(2013) Testing method for void content of fine aggregate
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2505	(2002) Methods of test for bulk density of

	aggregates and solid content in aggregates
KS F 2507	(2007) Method of test for soundness of aggregates by use of sodium sulfate
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine
KS F 2575	(2013) Testing method for flat or elongated particles in coarse aggregate
KS F 3501	(2013) Filler for hot mix asphalt pavement
KS M 2201	(2007) Straight Asphalt
KS M 2208	(2007) Viscosity-Graded asphalt cement for use pavement construction

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171	(1995) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate

1.2 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Hot-mix asphalt (HMA) designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course. Submit proposed Placement Plan, indicating lane widths, longitudinal joints, and transverse joints for each course or lift.

1.2.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 or KS F 2356 with the following changes:

a. Truck Scales. Weigh the asphalt mixture on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed at least annually by an approved calibration laboratory.

b. Testing Facilities. Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

c. Inspection of Plant. The Contracting Officer shall have access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

d. Storage Bins. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

1.2.2 Hauling Equipment

Trucks used for hauling hot-mix asphalt shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

1.2.3 Material Transfer Vehicle (MTV)

Material transfer Vehicles shall be required due to the improvement in smoothness and decrease in both physical and thermal segregation. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that can deliver material to the paver without making contact with the paver. The MTV shall be able to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. The Material Transfer Vehicle will have remixing and storage capability to prevent physical and thermal segregation.

1.2.4 Asphalt Pavers

Mechanical spreading and finishing equipment shall consist of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. The screed of the paver shall be capable of laying a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed. The screed will be equipped with a compaction device and it will be used during all placement.

1.2.4.1 Receiving Hopper

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

1.2.4.2 Automatic Grade Controls

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 9.14 m (30 feet) in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

1.2.5 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Equipment which causes excessive crushing of the aggregate shall not be used.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Placement Plan

SD-03 Product Data

Mix Design; G
Contractor Quality Control; G

SD-04 Samples

Asphalt Cement Binder
Aggregates

SD-06 Test Reports

Aggregates; G
QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G
Testing Laboratory

1.4 QUALITY ASSURANCE

The Government quality assurance (QA) program for this project is separate and distinct from the Contractor's quality control (QC) program specified in Part 3. Testing for acceptability of work will be performed by the Government or by an independent laboratory hired by the

Contracting Officer , except for grade and smoothness testing which shall be performed by the Contractor. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 1,800 metric tons. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus grade and smoothness measurements for the entire lot cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

1.4.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

1.4.2 Additional Sampling and Testing

The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be treated as a separate lot. Payment will be made for the quantity of HMA represented by these tests in accordance with the provisions of this section.

1.4.3 In-place Density

For determining in-place density, one random core (100 mm (4 inches) or 150 mm (6 inches) in diameter) will be taken at locations identified by the Government from the mat (interior of the lane) of each sublot, and one random core will be taken from the joint (immediately over joint) of each sublot, in accordance with ASTM D979/D979M. Fill all core holes with hot-mix. The core holes shall be dry and tack coated before filling. Each random core will be full thickness of the layer being placed. When the random core is less than 25 mm (1 inch) thick, it will not be included in the analysis. In this case, another random core will be taken. After air drying to meet the requirements for laboratory-prepared, thoroughly dry specimens, cores obtained from the mat and from the joints will be used for in-place density determination in accordance with ASTM D2726/D2726M or KS F 2353.

1.4.4 Surface Smoothness

Use one or of the following methods to test and evaluate surface smoothness of the finished surface of the pavement final grade. All testing shall be performed in the presence of the Contracting Officer .

Detailed notes of the results of the testing shall be kept and a copy furnished to the Government immediately after each day's testing. The profilograph method shall be used for all longitudinal and transverse testing, except where the runs would be less than 60 m (200 feet) in length and the ends where the straightedge shall be used. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer .

1.4.4.1 Smoothness Requirements

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 3 mm (1/8 inch) or more, and all pavements shall be within the tolerances specified in Table 3 when checked with an approved 4 m (12 feet) straightedge.

Table 3. Straightedge Surface Smoothness--Pavements

Pavement Category	Direction of Testing	Tolerance, mm(inches)
Runways and taxiway	Longitudinal	3(1/8)
	Transverse	6(1/4)
Shoulders (outside edge stripe)	Transverse	6 (1/4)
	Longitudinal	Not Required
Calibration hardstands and compass swinging bases	Longitudinal	3(1/8)
	Transverse	3(1/8)
All other airfields and helicopter paved areas	Longitudinal	6(1/4)
	Transverse	6(1/4)

b. Profilograph Testing: The finished surfaces of the pavements shall have no abrupt change of 3 mm (1/8 inch) or more, and all pavement shall have a Profile Index not greater than specified in Table 4 when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 60 m (200 feet), that direction shall be tested by the straightedge method and shall meet requirements specified above.

Table 4. Profilograph Surface Smoothness--Pavements		
Pavement Category	Direction of Testing	Maximum Specified Profile Index (mm/kminch/mile)
Runways	Longitudinal	110 (7)
	Transverse	(Use Straightedge)
Taxiways	Longitudinal	140 (9)
	Transverse	(Use Straightedge)
Shoulders (outside edge stripe)	Transverse	(Use Straightedge)
	Longitudinal	Not Required
Calibration Hardstands and Compass Swinging Bases		(Use Straightedge)
All Other Airfield and Helicopter Paved Areas	Longitudinal	140 (9)
	Transverse	140 (9)

1.4.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, the surface of the pavement in each entire lot shall be tested in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are diamond ground, these areas shall be retested immediately after grinding. The area corrected by grinding shall not exceed 10 percent of the total area of the lot. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines. The transverse lines shall be 4.5 m (15 feet) or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lines less than 6.1 m (20 feet) and at the third points for lanes 6.1 m (20 feet) or greater. Other areas having obvious deviations shall also be tested. Longitudinal testing lines shall be continuous across all joints.

a. Straightedge Testing. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

b. Profilograph Testing. Profilograph testing shall be performed using an approved California profilograph and procedures described in ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for the pavement. The "blanking band" shall be 5 mm (0.2 inches) wide and the "bump template" shall span 25 mm (1 inch) with an offset of 10 mm (0.4 inch). The profilograph shall be operated by an approved, factory-trained operator on the alignments specified above. A copy of the reduced tapes shall be furnished the Government at the end of each day's testing.

c. Bumps ("Must Grind" Areas). Any bumps ("must grind" areas) shown on the profilograph trace which exceed 10 mm (0.4 inch) in height shall be reduced by diamond grinding until they do not exceed 7.5 mm (0.3 inch) when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. At the Contractor's option, pavement areas, including ground areas, may be rechecked with the profilograph in order to record a lower Profile Index.

1.5 ENVIRONMENTAL REQUIREMENTS

The hot-mix asphalt shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 5. The temperature requirements may be waived by the Contracting Officer , if requested; however, all other requirements, including compaction, shall be met.

Table 5. Surface Temperature Limitations of Underlying Course

Mat Thickness, mm (inches)	Degrees C (F)
75 (3)or greater	4 (40)
Less than 75(3)	7 (45)

PART 2 PRODUCTS

2.1 AGGREGATES

Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The portion of material retained on the 4.75 mm (No. 4) sieve is coarse aggregate. The portion of material passing the 4.75 mm (No. 4) sieve and retained on the 0.075 mm (No. 200) sieve is fine aggregate. The portion passing the 0.075 mm (No. 200) sieve is defined as mineral filler. Submit sufficient materials to produce 90 kg (200 lb) of blended mixture for mix design verification. All aggregate test results and samples shall be submitted to the Contracting Officer at least 14 days prior to start of construction. Aggregate testing shall have been performed within 90 days of performing the mix design.

2.1.1 Coarse Aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. The coarse aggregate particles shall meet the following requirements:

a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131 or KS F 2508.

b. The sodium sulfate soundness loss shall not exceed 12 percent in accordance with ASTM C88 or KS F 2507 or KS F 2507, or the magnesium sulfate soundness loss shall not exceed 18 percent after five cycles when tested in accordance with ASTM C88.

c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171. Fractured faces shall be produced by crushing.

d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20 percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791 or KS F 2575.

e. Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 1200 kg/cubic meters (75 lb/cubic feet) when tested in accordance with ASTM C29/C29M or KS F 2505.

f. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.1.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles. The aggregate particles shall be free from coatings of clay, silt, or any objectionable material and shall contain no clay balls. The fine aggregate particles shall meet the following requirements:

a. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 15 percent by weight of total aggregate.

b. The individual fine aggregate sources shall have a sand equivalent value greater than 45 when tested in accordance with ASTM D2419 or KS F 2340.

c. The fine aggregate portion of the blended aggregate shall have an uncompacted void content greater than 45.0 percent when tested in accordance with ASTM C1252 or KS F 2384 Method A.

d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.1.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242/D242M or KS F 3501.

2.1.4 Aggregate Gradation

The combined aggregate gradation shall conform to gradations specified in Table 6, when tested in accordance with ASTM C136 or KS F 2502 and ASTM C117 or KS F 2309, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine. The JMF shall be within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 9 and 10 are applied.

Table 6. Aggregate Gradations

	Gradation 1	Gradation 2	Gradation 3
Sieve Size, mm (inch)	Percent Passing by Mass	Percent Passing by Mass	Percent Passing by Mass
25.0 (1)	100	---	---
19.0 (3/4)	90-100	100	---
12.5 (1/2)	68-88	90-100	100
9.5 (3/8)	60-82	69-89	90-100
4.75 (No.4)	45-67	53-73	58-78
2.36 (No.8)	32-54	38-60	40-60
1.18 (No.16)	22-44	26-48	28-48
0.60 (No.30)	15-35	18-38	18-38
0.30 (No.50)	9-25	11-27	11-27
0.15 (No.100)	6-18	6-18	6-18
0.075 (No.200)	3-6	3-6	3-6

2.2 ASPHALT CEMENT BINDER

Asphalt cement binder shall conform to ASTM D3381/D3381M Table 2, Viscosity Grade AC-10 or KS M 2208 Grade 2, AC-10; or ASTM D946/D946M Penetration Grade 60-70 or 85-100 or KS M 2201 grade 60-80 or 80-100. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Copies of these certifications shall be submitted to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Samples for this verification testing shall be obtained in accordance with ASTM D140/D140M and in the presence of the Contracting Officer . These samples shall be furnished to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit 20 L (5 gallon) sample of the asphalt cement specified for mix design verification and approval not less than 14 days before start of the test section.

2.3 MIX DESIGN

Develop the mix design. The Job Mix formula (JMF)shall have been developed and aggregates tested no earlier than 6 months before contract award. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 6. No hot-mix asphalt for payment shall be produced until a JMF has been approved. The hot-mix asphalt shall be designed using hand-held hammer procedures contained in AI MS-2 and the criteria shown in Table 7. Laboratory compaction temperatures for Polymer Modified Asphalts shall be as recommended by the asphalt cement manufacturer. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M or KS F 2352 is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. If an antistrip agent is required, it shall be provided at no additional cost to the Government. Sufficient materials to produce 90 kg (200 pounds) of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.

2.3.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section, including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade.

e. Number of blows of hammer per side of molded specimen.

f. Laboratory mixing temperature.

g. Lab compaction temperature.

h. Temperature-viscosity relationship of the asphalt cement.

i. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

j. Graphical plots and summary tabulation of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Summary tabulation shall include individual specimen data for each specimen tested.

k. Specific gravity and absorption of each aggregate.

l. Percent natural sand.

m. Percent particles with two or more fractured faces (in coarse aggregate).

n. Fine aggregate angularity.

o. Percent flat or elongated particles (in coarse aggregate).

p. Tensile Strength Ratio and wet/dry specimen test results.

q. Antistrip agent (if required).

r. List of all modifiers.

s. Percentage and properties (asphalt content, binder properties, and aggregate properties) of RAP in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

Table 7. Marshall Design Criteria

Test Property	75 Blow Mix	50 Blow Mix
Stability, N (pounds) minimum	9560 (2150)(1)	6000 (1350)(1)
Flow,0.25 mm(0.01 inch)	8-16(2)	8-18(2)
Air voids, percent	4(4)	4(4)
Percent Voids in mineral aggregate (minimum)	See Table 8	See Table 8
Dust Proportion(3)	0.8-1.2	0.8-1.2
TSR, minimum percent	75	75
TSR Conditioned Strength (minimum kPa (psi))	415 (60)	415 (60)

(1) This is a minimum requirement. The average during construction shall be significantly higher than this number to ensure compliance with the specifications.

(2) The flow requirement is not applicable for Polymer Modified Asphalts

(3) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the 0.075 mm(No. 200) sieve, divided by the effective asphalt content, in percent of total mass of the mixture.

(4) Select the JMF asphalt content corresponding to an air void content of 4 percent. Verify the other properties of Table 7 meet the specification requirements at this asphalt content.

Table 8. Minimum Percent Voids in Mineral Aggregate (VMA)(1)

Aggregate (See Table 6)	Minimum VMA, percent
Gradation 1	13

Table 8. Minimum Percent Voids in Mineral Aggregate (VMA)[1]	
Aggregate (See Table 6)	Minimum VMA, percent
Gradation 2	14
Gradation 3	15
(1) Calculate VMA in accordance with AI MS-2, based on ASTM D2726/D2726M or KS F 2353 bulk specific gravity for the aggregate.	

2.3.2 Adjustments to JMF

The JMF for each mixture shall be in effect until a new formula is approved in writing by the Contracting Officer . Should a change in sources of any materials be made, a new mix design shall be performed and a new JMF approved before the new material is used. The Contractor will be allowed to make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF shall be limited to plus or minus 4 percent on the 4.75 mm (No. 4) and coarser sieves; plus or minus 3 percent on the 2.36 mm (No. 8) to 0.30 mm (No. 50) sieves; and plus or minus 1 percent on the 0.15 mm (No. 100) sieve. Adjustments to the JMF shall be limited to plus or minus 1.0 percent on the 0.075 mm (No. 200) sieve. Asphalt content adjustments shall be limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, a new mix design shall be developed.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the approved Quality Control Plan. Hot-mix asphalt for payment shall not be produced until the quality control plan has been approved. The plan shall address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design and unique JMF identification code

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management and procedures to prevent contamination

e. Proportioning

f. Mixing and Transportation

g. Correlation of mechanical hammer to hand hammer. Determine the number of blows of the mechanical hammer required to provide the same density of the JMF as provided by the hand hammer. Use the average of three specimens per trial blow application.

h. Mixture Volumetrics

i. Moisture Content of Mixtures

j. Placing and Finishing

k. Joints

l. Compaction, including HMA-PCC joints

m. Surface Smoothness

n. Truck bed release agent

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site. It shall be equipped with heating and air conditioning units to maintain a temperature of 24 plus or minus 2.3 degrees C (75 plus or minus 36 degrees F). Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability, flow, in-place density, grade and smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

3.1.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph QUALITY ASSURANCE) by one of the following methods: extraction method in accordance with ASTM D2172/D2172M, Method A or B or KS F 2354, method A or B, the ignition method in accordance with the AASHTO T 308, ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M, provided each method is calibrated for the specific mix being used. For the extraction method, the weight of ash, as described in ASTM D2172/D2172M or KS F 2354, shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.1.3.2 Aggregate Properties

Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444 or ASTM D6307. For batch plants, aggregates shall be tested in accordance with ASTM C136 using actual batch weights to determine the combined aggregate gradation of the mixture. The specific gravity of each aggregate size grouping shall be determined for each 18,000 metric tons in accordance with ASTM C127 or ASTM C128. Fractured faces for gravel sources shall be determined for each 18,000 metric tons in accordance with COE CRD-C 171. The uncompacted void content of manufactured sand shall be determined for each 18,000 metric tons in accordance with ASTM C1252 Method A or KS F 2384.

3.1.3.3 Temperatures

Temperatures shall be checked at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.1.3.4 Aggregate Moisture

The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

3.1.3.5 Moisture Content of Mixture

The moisture content of the mixture shall be determined at least once per lot in accordance with AASHTO T 329.

3.1.3.6 Laboratory Air Voids, VMA, Marshall Stability and Flow

Mixture samples shall be taken at least four times per lot and compacted into specimens, using 50 75 blows per side with the Marshall hand-held hammer as described in ASTM D6926. After compaction, the laboratory air voids and VMA of each specimen shall be determined, as well as the Marshall stability and flow, as described in ASTM D6927.. The VMA shall be within the limits of Table 8.

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device may be used to monitor pavement density.

3.1.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraph QUALITY ASSURANCE.

3.1.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

3.1.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.1.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 9, as a minimum. These control charts shall be posted as directed by the Contracting Officer and shall be kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 9 applicable to the test parameter being plotted, and the Contractor's test results. Target values (JMF) shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. When the Suspension Limit is exceeded for individual values or running average values, the Contracting Officer Engineer has the option to require the Contractor to remove and replace the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Decisions concerning mix modifications shall be made based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action which shall be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 9. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
4.75 mm (No. 4)sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	6	8	4	5

Table 9. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
0.6 mm (No. 30)sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	4	6	3	4
0.075 mm (No. 200)sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values	1.4	2.0	1.1	1.5
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
VMA				
Gradation 1	13.3	13.0	13.5	13.0
Gradation 2	14.3	14.0	14.5	14.0
Gradation 3	15.3	15.0	15.0	15.0

Table 9 cont'd. Marshall Compaction
Stability, N (pounds) (minimum)

75 blow JMF	7830(1760)	7290(1640)	9560(2150)	9030(2030)
50 blow JMF	4230(950)	3690(830)	6000(1350)	5470(1230)
Flow, 0.25 mm (0.01 inches)				
75 blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.
50 blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

The asphalt cement material shall be heated avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 160 degrees C (325 degrees F) when added to the aggregates.

3.3 PREPARATION OF MINERAL AGGREGATE

The aggregate for the mixture shall be heated and dried prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 175 degrees C (350 degrees F) when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. The combined materials shall be mixed until the aggregate obtains a thorough and uniform coating of asphalt binder (testing in accordance with ASTM D2489/D2489M or KS F 2360 may be required by the Contracting Officer) and is thoroughly distributed throughout the mixture. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, the underlying course shall be cleaned of dust and debris. A prime coatand/ortack coat shall be applied in accordance with the contract specifications.

3.6 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section consisting of a maximum of 250 tons and two paver passes wide placed in two lanes, with a longitudinal cold joint. The test section shall be of the same depth as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. The test section shall be placed as part of the project pavement as approved by the Contracting Officer .

3.6.1 Sampling and Testing for Test Section

One random sample shall be taken at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. A portion of the same sample shall be tested for theoretical maximum density (TMD), aggregate gradation and asphalt content. An additional portion of the sample shall be tested to determine the Tensile Strength Ratio (TSR). Adjust the compactive effort as required to provide TSR specimens with an air void content of 7 plus/minus 1 percent. Four randomly selected cores shall be taken from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall be within the tolerances or exceed the minimum values shown in Table 10 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed.

Table 10. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
4.75 mm (No. 4)and larger	JMF plus or minus 8
2.36, 1.18, 0.60, and 0.30 mm (No. 8, No. 16, No. 30, and No. 50)	JMF plus or minus 6
0.15 and 0.075 mm (No. 100 and No. 200)	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	See Table 8
Tensile Strength Ratio (TSR) (At 7 percent plus/minus 1 percent air void content)	75 percent minimum
Conditioned Strength	415 kPa (60 psi)minimum
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0

Table 10. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 minimum
Table 10. cont'd - Marshall Compaction	
Stability, N (pounds) (Average of 3 specimens)	6000 (1350) 9560 (2150) minimum
Flow, 0.25 mm (0.01 inch) (Average of 3 specimens)	8 - 16 8 - 18

3.6.2 Additional Test Sections

If the initial test section should prove to be unacceptable, the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.7 TESTING LABORATORY

The laboratories used to develop the JMF, perform Contractor Quality Control testing, and for Government acceptance testing shall meet the requirements of ASTM D3666. All required test methods shall be performed by an accredited laboratory. The Government will inspect the laboratory equipment and test procedures prior to the start of hot-mix operations for conformance with ASTM D3666. The laboratory shall maintain this validation for the duration of the project. Submit a certification of compliance signed by the manager of the laboratory stating that it meets these requirements to the Contracting Officer prior to the start of construction. The certification shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.8 TRANSPORTING AND PLACING

3.8.1 Transporting

The hot-mix asphalt shall be transported from the mixing plant to the site in clean, tight vehicles. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Adequate artificial lighting shall be provided for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 60 degrees C (140 degrees F).

3.8.2 Placing

The mix shall be placed in lifts of adequate thickness and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, the mixture shall be placed to the full width by an asphalt paver; it shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. Waste mixture shall not be broadcast onto the mat or recycled into the paver hopper. Collect waste mixture and dispose off site. The speed of the paver shall be regulated to eliminate pulling and tearing of the asphalt mat. Placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 3 m (10 feet). The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 300 mm (1 feet); however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 3 m (10 feet) from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 3 m (10 feet). On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.9 COMPACTION OF MIXTURE

3.9.1 General

a. After placing, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be compacted as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used are at the discretion of the Contractor, with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Correct at once any displacement occurring as a result of reversing the direction of the roller, or from any other cause.

b. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened, but excessive water will not be permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers. Remove the full depth of any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective, replace with fresh hot mixture and immediately compact to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.9.2 Segregation

The Contracting Officer can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Contracting Officer has the option to sample the material and have it tested and compared to the aggregate gradation, asphalt content, and in-place density requirements in Table 10. If the material fails to meet these specification requirements, the extent of the segregated material will be removed and replaced the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.10 JOINTS

The formation of joints shall be made ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.10.1 Transverse Joints

The roller shall not pass over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. The cutback material shall be removed from the project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

3.10.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 80 degrees C (175 degrees F) at the time of placing the adjacent lane), or otherwise defective, shall be cut back a maximum of 75 mm (3 inches) from the top edge of the lift with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. All cutback material shall be removed from the project. Cutting equipment that uses water as a cooling or cutting agent shall not be permitted. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint.

3.10.3 HMA-Portland Cement Concrete Joints

Joints between HMA and PCC will require specific construction procedures for the HMA. The following criteria are applicable to the first 3 m (10 feet) or paver width of HMA adjacent to the PCC.

a. Pave the HMA side of the joint in a direction parallel to the joint.

b. Place the HMA side sufficiently high so that when fully compacted the HMA will be greater than 3 mm (1/8 inch) but less than 6 mm (1/4 inch) higher than the PCC side of the joint.

c. Compaction shall be provided with steel wheel rollers and at least one rubber tire roller. The rubber tire roller shall be at least 18 metric tons in weight and have tires that are inflated to at least 620 kPa (90 psi). Avoid spalling the PCC during placement and compaction of the HMA. Steel wheel rollers shall be operated in a way that prevents spalling the PCC. Any damage to PCC edges or joints shall be repaired as directed by the Contracting Officer. If damage to the PCC joint or edge exceeds a total of 1 m (3 feet), the PCC panel shall be removed and replaced at no additional expense to the Government.

d. After compaction is finished the HMA shall be leveled by grinding so that the HMA side is less than 3 mm (1/8 inch) higher than the PCC side. The HMA immediately adjacent to the joint shall not be lower than the PCC after the grinding operation. Transition the grinding into the HMA in a way that ensures good smoothness and provides drainage of water. The joint and adjacent materials when completed shall meet all of the requirements for grade and smoothness. Measure smoothness across the PCC-HMA joint using a 4 m (12 feet) straightedge. The acceptable tolerance is 3 mm (1/8 inch).

e. Consider the HMA next to the PCC as a separate lot for evaluation. Lots are based on individual lifts. Do not comingle cores from different lifts for density evaluation purposes. Take four cores for each lot of material placed adjacent to the joint. The size of lot shall be 3 m (10 feet) wide by the length of the joint being paved. Lots are based on individual lifts and shall not be comingled for density evaluation purposes. Locate the center of each of the four cores 150 mm (6 inches) from the edge of the concrete. Take each core at a random location along the length of the joint. The requirements for density for this lot, adjacent to the joint, are the same as that for the mat specified earlier.

f. All procedures, including repair of damaged PCC, shall be in accordance with the approved Quality Control Plan.

-- End of Section --

SECTION 32 12 16

HOT-MIX ASPHALT (HMA) FOR ROADS
08/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 320	(2010) Standard Specification for Performance-Graded Asphalt Binder

ASPHALT INSTITUTE (AI)

AI MS-02	(1997 6th Ed) Mix Design Methods
AI MS-22	(2001; 2nd Ed) Construction of Hot-Mix Asphalt Pavements

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C1252	(2006) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates

ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D1461	(2011) Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D2172/D2172M	(2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2419	(2009) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D242/D242M	(2009) Mineral Filler for Bituminous Paving Mixtures
ASTM D2489/D2489M	(2008) Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D2950/D2950M	(2011) Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3665	(2012) Random Sampling of Construction Materials
ASTM D3666	(2013) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5444	(2008) Mechanical Size Analysis of Extracted Aggregate
ASTM D6307	(2010) Asphalt Content of Hot Mix Asphalt by Ignition Method

ASTM D6925	(2009) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D6926	(2010) Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus
ASTM D6927	(2006) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D995	(1995b; R 2002) Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2340	(2009) Standard test method for sand equivalent value of soils and fine aggregate
KS F 2352	(2005) Testing method for effect of water on cohesion of compacted asphalt mixtures
KS F 2353	(2010) Testing method for bulk specific gravity and density of compacted bituminous mixtures using paraffin-coated specimens
KS F 2354	(2013) Testing method for bitumen content from bituminous paving mixtures
KS F 2356	(2013) Requirements of mixing plants for hot mix asphalt
KS F 2360	(2006) Testing Method for Degree of Particles Coating of Asphalt -aggregate Mixture
KS F 2372	(2005) Standard test method for moisture or volatile distillates in asphalt paving mixtures
KS F 2384	(2013) Testing method for void content of fine aggregate
KS F 2507	(2007) Method of test for soundness of aggregates by use of sodium sulfate
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine
KS F 2541	(2002) Testing method for determination of

	aggregates crushing value
KS F 2575	(2013) Testing method for flat or elongated particles in coarse aggregate
KS F 3501	(2013) Filler for hot mix asphalt pavement
KS M 2201	(2007) Straight Asphalt
KS M 2208	(2007) Viscosity-Graded asphalt cement for use pavement construction

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2002) Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171	(1995) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate

1.2 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and roll, finish, and approve it before the placement of the next course.

1.2.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of ASTM D995 or KS F 2356 with the following changes:

a. Truck Scales. Weigh the asphalt mixture on approved, certified scales at the Contractor's expense. Inspect and seal scales at least annually by an approved calibration laboratory.

b. Testing Facilities. Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

c. Inspection of Plant. Provide the Contracting Officer with access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

d. Storage Bins. Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

(1) The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.

(2) The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

1.2.2 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

1.2.3 Asphalt Pavers

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

1.2.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

1.2.3.2 Automatic Grade Controls

If an automatic grade control device is used, equip the paver with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. Provide controls capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 9.14 m (30 feet) in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

1.2.4 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor Quality Control; G

SD-03 Product Data

Mix Design; G
Job Mix Formula

SD-06 Test Reports

Aggregates; G
Material Acceptance; G
Asphalt Content
Gradation
Temperatures
Aggregate Moisture
Moisture Content of Mixture
Laboratory Air Voids, Marshall Stability and Flow
In-Place Density
Grade and Smoothness

SD-07 Certificates

Asphalt Cement Binder
Testing Laboratory

1.4 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived by the Contracting Officer, if requested; however, all other requirements, including compaction, shall be met.

Table 3. Surface Temperature Limitations of Underlying Course

Mat Thickness, mm	Degrees C
75 or greater	4
Less than 75	7

Table 3. Surface Temperature Limitations of Underlying Course

Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 AGGREGATES

Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. Submit sufficient materials to produce 90 kg (200 lb) of blended mixture for mix design verification. The portion of material retained on the 4.75 mm (No. 4) sieve is coarse aggregate. The portion of material passing the 4.75 mm (No. 4 sieve and retained on the 0.075 mm (No. 200) sieve is fine aggregate. The portion passing the 0.075 mm (No. 200) sieve is defined as mineral filler. Submit all aggregate test results and samples to the Contracting Officer at least 14 days prior to start of construction.

2.1.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. All individual coarse aggregate sources shall meet the following requirements:

a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131 or KS F 2508.

b. The percentage of loss shall not be greater than 18 percent after five cycles when tested in accordance with ASTM C88 or KS F 2507 using magnesium sulfate or 12 percent when using sodium sulfate.

c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171 or KS F 2541. Fractured faces shall be produced by crushing.

d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20% percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791 or KS F 2575.

e. Slag shall be air-cooled, blast furnace slag, with a compacted weight of not less than 1200 kg/cubic meter (75 lb/cu ft) when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.1.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles free from coatings of clay, silt, or any objectionable material and containing no clay balls.

a. All individual fine aggregate sources shall have a sand equivalent value not less than 45 when tested in accordance with ASTM D2419 or KS F 2340.

b. The fine aggregate portion of the blended aggregate shall have an uncompacted void content not less than 45.0 percent when tested in accordance with ASTM C1252 Method A or KS F 2384.

c. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 25 percent by weight of total aggregate.

d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M

2.1.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242/D242M or KS F 3501.

2.1.4 Aggregate Gradation

The combined aggregate gradation shall conform to gradations specified in Table 4, when tested in accordance with ASTM C136 and ASTM C117, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine.

Table 4. Aggregate Gradations

Sieve Size, mm	Gradation 1 Percent Passing by Mass	Gradation 2 Percent Passing by Mass	Gradation 3 Percent Passing by Mass
25.0	100	---	---
19.0	76-96	100	---
12.5	68-88	76-96	100
9.5	60-82	69-89	76-96
4.75	45-67	53-73	58-78
2.36	32-54	38-60	40-60
1.18	22-44	26-48	28-48
0.60	15-35	18-38	18-38
0.30	9-25	11-27	11-27
0.15	6-18	6-18	6-18
0.075	3-6	3-6	3-6

Table 4. Aggregate Gradations

Sieve Size, inch	Gradation 1 Percent Passing by Mass	Gradation 2 Percent Passing by Mass	Gradation 3 Percent Passing by Mass
1	100	---	---
3/4	76-96	100	---
1/2	68-88	76-96	100
3/8	60-82	69-89	76-96

Table 4. Aggregate Gradations

Sieve Size, inch	Gradation 1 Percent Passing by Mass	Gradation 2 Percent Passing by Mass	Gradation 3 Percent Passing by Mass
No. 4	45-67	53-73	58-78
No. 8	32-54	38-60	40-60
No. 16	22-44	26-48	28-48
No. 30	15-35	18-38	18-38
No. 50	9-25	11-27	11-27
No. 100	6-18	6-18	6-18
No. 200	3-6	3-6	3-6

2.2 ASPHALT CEMENT BINDER

Submit a 20 L (5 gallon sample for mix design verification. Asphalt cement binder shall conform to AASHTO M 320. As an alternate, ASTM D3381/D3381M Table 4, Viscosity Grade AC-10 or ASTM D946/D946M penetration grade 85-100 or 60-70, or KS M 2201 or KS M 2208 . Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with ASTM D140/D140M and in the presence of the Contracting Officer. Furnish these samples to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit samples of the asphalt cement specified for approval not less than 14 days before start of the test section. Submit copies of certified test data, amount, type and description of any modifiers blended into the asphalt cement binder.

2.3 MIX DESIGN

Develop the mix design. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF). Submit proposed JMF; do not produce hot-mix asphalt for payment until a JMF has been approved. The hot-mix asphalt shall be designed in accordance with Marshall (MS-02), Superpave (SP-2), or Hveem (MS-02) procedures and the criteria shown in Table 5. Use the hand-held hammer to compact the specimens for Marshall mix design. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M or KS F 2352 is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an approved anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. Provide an antistrip agent, if required, at no additional cost. Sufficient materials to produce 90 kg (200 pounds) of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.

2.3.1 JMF Requirements

Submit in writing the job mix formula for approval at least 14 days prior to the start of the test section including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade.

e. Number of blows of hand-held hammer per side of molded specimen. (NA for Superpave)

f. Number of gyrations of Superpave gyratory compactor, (NA for Marshall mix design)

g. Laboratory mixing temperature.

h. Lab compaction temperature.

i. Temperature-viscosity relationship of the asphalt cement.

j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

k. Graphical plots of stability (NA for Superpave), flow (NA for Superpave), air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-02.

l. Specific gravity and absorption of each aggregate.

m. Percent natural sand.

n. Percent particles with 2 or more fractured faces (in coarse aggregate).

o. Fine aggregate angularity.

p. Percent flat or elongated particles (in coarse aggregate).

q. Tensile Strength Ratio(TSR).

r. Antistrip agent (if required) and amount.

s. List of all modifiers and amount.

t. Correlation of hand-held hammer with mechanical hammer (NA for Superpave).

u. Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

Table 5. Mix Design Criteria

Test Property	50 Blows Mix or 50 Gyrations	75 Blows or Mix 75 Gyrations
Stability, newtons, minimum (NA for Superpave)	*4450	*8000

Table 5. Mix Design Criteria

Test Property	50 Blows Mix or 50 Gyrations	75 Blows or Mix 75 Gyrations
Flow, 0.25 mm (NA for Superpave)	8-18	8-16
Air voids, percent	3-5	3-5
Percent Voids in mineral aggregate (VMA), (minimum)		
Gradation 1	13.0	13.0
Gradation 2	14.0	14.0
Gradation 3	15.0	15.0
TSR, minimum percent	75	75

Table 5. Mix Design Criteria

Test Property	50 Blows or 50 Gyrations	75 Blows or 75 Gyrations
Stability, pounds, minimum (NA for Superpave)	*1000	*1800
Flow, 0.01 inch (NA for Superpave)	8-18	8-16
Air voids, percent	3-5	3-5
Percent Voids in mineral aggregate VMA, (minimum)		
Gradation 1	13.0	13.0
Gradation 2	14.0	14.0
Gradation 3	15.0	15.0
TSR, minimum percent	75	75

* This is a minimum requirement. The average during construction shall be significantly higher than this number to ensure compliance with the specifications.
** Calculate VMA in accordance with AI MS-02, based on ASTM C127 and ASTM C128 or KS F 2353 bulk specific gravity for the aggregate.

2.3.2 Adjustments to Field JMF

Keep the Laboratory JMF for each mixture in effect until a new formula is approved in writing by the Contracting Officer. Should a change in sources of any materials be made, perform a new laboratory jmf design and a new JMF approved before the new material is used. The Contractor will be allowed to adjust the Laboratory JMF within the limits specified below to optimize mix volumetric properties with the approval of the Contracting Officer. Adjustments to the Laboratory JMF shall be applied to the field (plant) established JMF and limited to those values as shown. Adjustments shall be targeted to produce or nearly produce 4 percent voids total mix (VTM).

TABLE 6. Field (Plant) Established JMF Tolerances

Sieves	Adjustments (plus or minus), percent
12.5 mm	3
4.75 mm	3
2.36 mm	3
0.075 mm	1
Binder Content	0.4

TABLE 6. Field (Plant) Established JMF Tolerances

Sieves	Adjustments (plus or minus), percent
1/2 inch	3
No. 4	3
No. 8	3
No. 200	1
Binder Content	0.40

If adjustments are needed that exceed these limits, develop a new mix design. Tolerances given above may permit the aggregate grading to be outside the limits shown in Table 4; while not desirable, this is acceptable, except for the 0.075 mm (No. 200 sieve, which shall remain within the aggregate grading of Table 4.

2.4 RECYCLED HOT MIX ASPHALT

Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement to produce a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 50 mm (2 inches). Design the recycled HMA mix using procedures contained in AI MS-02 and AI MS-22. The job mix shall meet the requirements of paragraph MIX DESIGN. The amount of RAP shall not exceed 30 percent.

2.4.1 RAP Aggregates and Asphalt Cement

The blend of aggregates used in the recycled mix shall meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt in the RAP for the mixture design according to ASTM D2172/D2172M or ASTM D6307 using the appropriate dust correction procedure.

2.4.2 RAP Mix

The blend of new asphalt cement and the RAP asphalt binder shall meet the dynamic shear rheometer at high temperature and bending beam at low temperature, penetration, and viscosity requirements in paragraph ASPHALT CEMENT BINDER. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph ASPHALT CEMENT BINDER.

PART 3 EXECUTION

3.1 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 160 degrees C (325 degrees F) when added to the aggregates. Performance-Graded (PG) asphalts shall be within the temperature range of 174 degrees C (345 degrees F when added to the aggregate.

3.2 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 175 degrees C (350 degrees F) when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but no less than 25 seconds for batch plants. Establish the wet mixing time for all plants based on the procedure for determining the percentage of coated particles described in ASTM D2489/D2489M or KS F 2360, for each individual plant and for each type of aggregate used. The wet mixing time will be set to at least achieve 95 percent of coated particles. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461 or KS F 2372.

3.4 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, clean the underlying course of dust and debris. Apply a prime coat and/or tack coat in accordance with the contract specifications.

3.5 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 75 - 150 m (250 - 500 feet) long and two paver passes wide placed for two lanes, with a longitudinal cold joint. The test section shall be of the same thickness as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment and personnel used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. Place the test section as part of the project pavement, as approved by the Contracting Officer.

3.5.1 Sampling and Testing for Test Section

Take one random sample at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Take four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall be within the tolerances shown in Table 7 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed. The test section shall be paid for with the first lot of paving

Table 7. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
4.75 mm and larger	JMF plus or minus 8
2.36, 1.18, 0.60, and 0.30 mm	JMF plus or minus 6
0.15 and 0.075 mm	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	13 minimum
Stability, newtons (Average of 3 specimens) (NA for Superpave)	4450 minimum for 50 blows 8000 minimum for 75 blows
Flow, 0.25 mm (Average of 3 specimens) (NA for Superpave)	8 - 18 for 50 blows 8 - 16 for 75 blows
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 - 92.5

Table 7. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0

Table 7. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
VMA, Percent (Average of 3 specimens)	13 minimum
Stability, pounds (Average of 3 specimens) (NA for superpave)	1000 minimum for 50 blows 1800 minimum for 75 blows
Flow, 0.01 inches (Average of 3 specimens) (NA for superpave)	8 - 18 for 50 blows 8 - 16 for 75 blows
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 - 92.5

3.5.2 Additional Test Sections

If the initial test section should prove to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures and place a second test section. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.6 TESTING LABORATORY

Submit certification of compliance and Plant Scale Calibration Certification. Use a laboratory to develop the JMF that meets the requirements of ASTM D3666. A statement signed by the manager of the laboratory stating that it meets these requirements or clearly listing all deficiencies shall be submitted to the Contracting Officer prior to the start of construction. The statement shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

Transport the hot-mix asphalt from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 60 degrees C (140 degrees F). To deliver mix to the paver, use a material transfer vehicle operated to produce continuous forward motion of the paver.

3.7.2 Placing

Place and compact the mix at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; it shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and conform to the grade and contour indicated. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 3 m (10 feet). The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 300 mm (1 foot); however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 3 m (10 feet) from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 3 m (10 feet). On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.8 COMPACTION OF MIXTURE

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened but excessive water will not be permitted. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective shall be removed full depth, replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.9 JOINTS

The formation of joints shall be performed ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing material at the joint. Remove the cutback material from the project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 80 degrees C (175 degrees F) at the time of placing adjacent lanes), or otherwise defective, shall be cut back a maximum of 75 mm (3 inches) from the top of the course with a cutting wheel to expose a clean, sound vertical surface for the full depth of the course. All cutback material shall be removed from the project. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint. The Contractor will be allowed to use an alternate method if it can be demonstrated that density, smoothness, and texture can be met.

3.10 CONTRACTOR QUALITY CONTROL

3.10.1 General Quality Control Requirements

Develop and submit an approved Quality Control Plan. Submit aggregate and QC test results. Do not produce hot-mix asphalt for payment until the quality control plan has been approved addressing all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management

e. Proportioning

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Finishing

j. Joints

k. Compaction

l. Surface Smoothness

3.10.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site and meeting the pertinent requirements in ASTM D3666. Laboratory facilities shall be kept clean and all equipment maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

3.10.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability (NA for Superpave), flow (NA for Superpave), in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.10.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph MATERIAL ACCEPTANCE) by one of the following methods: the extraction method in accordance with ASTM D2172/D2172M, Method A or B or KS F 2354, the ignition method in accordance with ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M. Calibrate the ignition oven or the nuclear gauge for the specific mix being used But trichloroethane shall not be used as a reagent in case of KS F 2354. For the extraction method, determine the weight of ash, as described in ASTM D2172/D2172M, as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.10.3.2 Gradation

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444. When asphalt content is determined by the ignition oven or nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test aggregates in accordance with ASTM C136 using actual batch weights to determine the combined aggregate gradation of the mixture.

3.10.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.10.3.4 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.

3.10.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with ASTM D1461 or KS F 2372 or an approved alternate procedure.

3.10.3.6 Laboratory Air Voids, Marshall Stability and Flow

Take mixture samples at least four times per lot compacted into specimens, using 50, 75 blows per side with the hand-held Marshall hammer as described in ASTM D6926. When the Superpave gyratory compactor is used, mixes will be compacted to 75gyrations in accordance with ASTM D6925. Hot-mix provided under the DOT Superpave option shall be compacted in accordance with the DOT requirements. After compaction, determine the laboratory air voids of each specimen. Stability and flow shall be determined for the Marshall-compacted specimens, in accordance with ASTM D6927.

3.10.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge may be used to monitor pavement density in accordance with ASTM D2950/D2950M.

3.10.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraphs MATERIAL ACCEPTANCE.

3.10.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process may be performed at the Contractor's option.

3.10.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.10.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.10.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. These control charts shall be posted as directed by the Contracting Officer and kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the Contractor's test results. Target values from the JMF shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

(Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

Parameter to be Plotted	Individual Samples Action Limit	Individual Samples Suspension Limit	Running Average of Last Four Samples Action Limit	Running Average of Last Four Samples Suspension Limit
4.75 mm sieve, Cumulative % Passing, deviation from JMF target; plus or minus values	6	8	4	5
0.6 mm sieve, Cumulative % Passing, deviation from JMF target; plus or minus values	4	6	3	4
0.075 mm sieve, Cumulative % Passing, deviation from JMF target; plus or minus values	1.4	2.0	1.1	1.5
Stability, newtons (minimum) (NA for Superpave)				
75 Blow JMF	8000	7560	8440	8000
50 Blow JMF	4450	4000	4900	4450
Flow, 0.25 mm (NA for Superpave)				
75 Blow JMF	8 min. 16 max.	7 min. 17 max.	9 min. 15 max.	8 min. 16 max.
50 Blow JMF	8 min. 18 max.	7 min. 19 max.	9 min. 17 max.	8 min. 18 max
Asphalt content, % deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, % deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, % of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, % of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment)			

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

Parameter to be Plotted	Individual Samples: Action Limit	Individual Samples: Suspension Limit	Running Average of Last Four Samples: Action Limit	Running Average of Last Four Samples: Suspension Limit
No. 4 sieve, Cumulative % Passing, deviation from JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative % Passing, deviation from JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative % Passing, deviation from JMF target; plus or minus values	1.4	2.0	1.1	1.5
Stability, pounds (minimum) (NA for Superpave)				
75 Blow JMF	1800	1700	1900	1800
50 Blow JMF	1000	900	1100	1000
Flow, 0.01 inches (NA for Superpave)				
75 Blow	8 min. 16 max.	7 min. 17 max.	9 min. 15 max.	8 min. 16 max.
50 Blow	8 min. 18 max.	7 min. 19 max.	9 min. 17 max.	8 min. 18 max.
Asphalt content, % deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, % deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, % of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, % of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

3.11 MATERIAL ACCEPTANCE

Testing for acceptability of work will be performed by an independent laboratory hired by the Contractor. Forward test results daily to the Contracting Officer. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 2000 metric (2000 short tons. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

3.11.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

3.11.2 Additional Sampling and Testing

The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

3.11.3 Grade

The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than 15 mm (0.05 foot) from the plan grade established and approved at site of work. Finished surfaces at juncture with other pavements shall coincide with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 7.6 m (25 feet), or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Within 5 working days, after the completion of a particular lot incorporating the final wearing surface, test the final wearing surface of the pavement for conformance with the specified plan grade. When more than 5 percent of all measurements made within a lot are outside the 15 mm (0.05 foot) tolerance, the Contractor shall remove at least 25 mm (1 inch) of material depth ; the Contractor shall then replace the lift with hot-mix asphalt to meet specification requirements, at no additional cost to the Government. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

3.11.4 Surface Smoothness

Use one of the following methods to test and evaluate surface smoothness of the pavement. Perform all testing in the presence of the Contracting Officer. Keep detailed notes of the results of the testing and furnish a copy to the Government immediately after each day's testing. Use the profilograph method for all longitudinal testing, except where the runs would be less than 60 m (200 feet) in length and the ends where the straightedge will be used. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer.

3.11.4.1 Smoothness Requirements

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 6 mm (1/4 inch) or more, and all pavements shall be within the tolerances of 6 mm (1/4 inch) in both the longitudinal and transverse directions, when tested with an approved 4 m (12 feet) straightedge.

b. Profilograph Testing: The finished surfaces of the pavements shall have no abrupt change of 3 mm (1/8 inch) or more, and each 0.1 km (0.1 mile segment of each pavement lot shall have a Profile Index not greater than 140 mm/km (9 inches/mile) when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 60 m (200 feet), that direction shall be tested by the straightedge method and shall meet requirements specified above.

3.11.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are ground, these areas shall be retested immediately after grinding. Test each lot of the pavement in both a longitudinal and a transverse direction on parallel lines. Set the transverse lines 4.5 m (15 feet) or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lanes less than 6.1 m (20 feet) wide and at the third points for lanes 6.1 m (20 feet) or wider. Also test other areas having obvious deviations. Longitudinal testing lines shall be continuous across all joints.

a. Straightedge Testing. Hold the straightedge in contact with the surface and move it ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

b. Profilograph Testing. Perform profilograph testing using approved equipment and procedures described in CTM 526. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each 0.1 km (0.1 mile) segment of each pavement lot. Grade breaks on parking lots shall be accommodated by breaking the profile segment into shorter sections and repositioning the blanking band on each segment. The "blanking band" shall be 5 mm (0.2 inches) wide and the "bump template" shall span 25 mm (1 inch) with an offset of 7.5 mm (0.3 inch). Compute the Profile Index for each pass of the profilograph in each 0.1 km (0.1 mile) segment. The Profile Index for each segment shall be the average of the Profile Indices for each pass in each segment. The profilograph shall be operated by an approved operator. Furnish a copy of the reduced tapes to the Government at the end of each day's testing.

c. Bumps ("Must Grind" Areas). Bumps ("must grind" areas) shown on the profilograph trace which exceed 5.0 mm 0.2 inch in height shall be reduced by diamond grinding until they do not exceed 5.0 mm 0.2 inch when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. At the Contractor's option, pavement areas, including ground areas, may be rechecked with the profilograph in order to record a lower Profile Index.

-- End of Section --

SECTION 32 12 37

FUEL-RESISTANT (COAL TAR) SEALER
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2939	(2003) Emulsified Bitumens Used as Protective Coatings
ASTM D5727/D5727M	(2000; R 2011) Emulsified Refined Coal Tar (Mineral Colloid Type)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates

1.2 SYSTEM DESCRIPTION

Machines, tools, and equipment used in the performance of the work will be approved before the work is started and shall be maintained in satisfactory condition.

1.2.1 Mixing

Mix the sealer in a mobile batch mixer of a type approved by the Contracting Officer. Provide a mixer capable of producing a uniform mixture of coal-tar emulsion , additives, and aggregate. The mixing unit shall have suitable mixing blades to combine the predetermined quantities of materials into a homogeneous slurry.

1.2.2 Application

1.2.2.1 Squeegee Application

Attach a variable-width mechanical-type squeegee to the mobile-application vehicle to place the slurry. Maintain the attached squeegee with flexible material in contact with the pavement surface to control application and prevent excessive loss of sealer mixture from the spreader on varying grades and crown. Provide a squeegee capable of adjustments to ensure a uniform spread; the mobile-application vehicle shall discharge the sealer to provide satisfactory application. Provide the vehicle with a water tank, pump, and spray bar for fogging the pavement surface ahead of the spreader box. Keep the spreader box clean; buildup of sealer and aggregate on the squeegee and spreader box will not be permitted.

1.2.2.2 Spray Application

The spray vehicle may be self-propelled or towed, designed and equipped to apply a uniform mixture of sealer and aggregate at rates ranging from 0.45 to 3.17 L/square meter (0.10 to 0.70 gallons/square yard). Include with sprayer equipment a separate power unit, agitated tank, spray bar, hand spray wand, and suitable pump and plumbing for handling sealer and aggregate.

1.2.3 Cleaning Equipment

Provide cleaning equipment consisting of power brooms, power blowers, power vacuums, air compressors, hand brooms, and other equipment as needed. The equipment shall be suitable for cleaning the surface and cracks in the existing pavement.

1.2.4 Hand Tools

Provide hand tools consisting of hand squeegees, shovels, and other equipment as necessary to perform the work.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sealer Mixture

SD-06 Test Reports

Sealer Materials; G

1.4 QUALITY ASSURANCE

1.4.1 Sampling

Furnish aggregate samples in accordance with ASTM D75/D75M. Samples of coal-tar emulsion, unless otherwise specified, shall be in accordance with ASTM D140/D140M. Furnish additional samples of materials as required.

1.4.2 Testing

Test Sealer Materials to establish compliance with the specified requirements. Perform quality control testing by an approved commercial testing laboratory or by Contractor testing, subject to approval by the Contracting Officer. Submit samples or certified test results of the materials, 7 days prior to the beginning of work. No material will be used until it has been approved.

1.4.3 Calibration Test

Furnish equipment, materials, and labor as necessary to calibrate equipment used to place the sealer. Make calibrations with the approved job materials prior to applying the sealer materials to the prepared surface. The manufacturer shall provide a method of calibration for all commercial equipment.

1.4.4 Trial Application

Prior to applying the sealer mixture, place a test section at least 30 meters (100 feet) long and two squeegee widths wide using the approved materials and equipment. Place the sealer mixture in accordance with the specified requirements. Determine the rate of application for compliance to specification requirements. If the test section does not conform to the specification requirements, make necessary adjustments, and construct additional test sections at the Contractor's expense for conformance to the specifications. Where test sections do not conform to the specification requirements, remove the sealer mixture by milling, grinding, or another approved method. Test sections that conform to all specification requirements may become part of the accepted sealed surface.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for contamination and damage, unload, and store them with a minimum of handling. Cover or store aggregates to keep them dry. Store the coal-tar emulsion according to the manufacturer's recommendations. Remove from the jobsite materials determined by the Contracting Officer to be contaminated, damaged, or failing to meet specification requirements and replace them at no additional cost to the Government.

1.6 WEATHER LIMITATIONS

Do not apply sealer if air or pavement temperatures are below 10 degrees C (50 degrees F) or if there is any possibility that the sealer will freeze before it has cured, unless otherwise directed by the Contracting Officer. Do not place any sealer when rain or other impending weather conditions will prevent proper curing of the sealer mixture.

PART 2 PRODUCTS

2.1 AGGREGATE

Provide aggregates which are either natural or manufactured angular aggregate composed of clean, hard, durable, uncoated particles free from clay and other objectionable material when tested in accordance with ASTM C142/C142M. The aggregate shall fall within one of the gradation ranges given in Table I, when tested in accordance with ASTM C136. The actual gradation can fall anywhere within the types listed, provided that at least 70 percent of the aggregate falls within two consecutive sieve sizes as given in Table I.

TABLE I.
AGGREGATE GRADATION RANGES AND CORRESPONDING
MINIMUM SEALER MIXTURE APPLICATION RATES

SIEVE SIZE	PERCENT PASSING		
	COARSE	MEDIUM	FINE
1.180 mm (No. 16)	100	100	100
0.850 mm (No. 20)	85-100	98-100	100
0.600 mm (No. 30)	25-85	85-100	98-100
0.425 mm (No. 40)	5-25	25-85	85-100
0.300 mm (No. 50)	2-10	5-25	25-85
0.212 mm (No. 70)	--	2-10	5-25
0.150 mm (No. 100)	0-2	0-4	2-10
0.106 mm (No. 140)	--	0-2	0-2
Note: Minimum sealer mixture application rate liter/square meter (gallon/square yard)	0.30	0.20	0.15

2.2 WATER

Add only potable water to the sealer mixture. The temperature of the water added during mixing shall be at least 10 degrees C (50 degrees F). The pH of the water shall conform to the requirements of the coal tar emulsion manufacturer.

2.3 COAL-TAR EMULSION

Provide base coal-tar emulsion (mineral colloid type) meeting the requirements of ASTM D5727/D5727M.

2.4 POLYMER ADDITIVE

Use the type and make of polymer additive recommended by the coal-tar emulsion manufacturer.

2.5 SEALER MIXTURE

Submit a copy of the mixture proportions that meet all the requirements of this specification. Determine the exact proportions of coal tar, water, polymer additive, and aggregate to be used in the preparation of the sealer by laboratory mix design furnished by the Contractor from a laboratory approved by the Contracting Officer. The sealer mixture shall meet the requirements as specified in Table II. Mix the sealer components to produce a homogeneous mixture that adequately suspends the aggregate in the mix.

TABLE II. PHYSICAL PROPERTIES OF SEALER MIXTURES

Property	Requirement	Referenced Test Method
Drying time, firm set	8 hours maximum	ASTM D2939
Resistance to Kerosene	No penetration or loss of adhesion	ASTM D2939

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Prior to application of the sealer mixture, clean the existing pavement surface and repair unsatisfactory areas. Remove failed pavement, base, subbase, or subgrade material and replace them with new materials. Areas patched or repaired with asphalt cold mix should be cured for 90 days, while those repaired with hot-mix asphalt should cure for 30 days prior to seal coating the surface.

3.1.1 Cracks

Treat cracks in the surface, not due to structural deficiencies, as outlined below: Cracks less than or equal to 6 mm (1/4 inch) wide should be cleaned with compressed air. Cracks larger than 6 mm (1/4 inch) but less than 19 mm (3/4 inch) in width shall be cleaned with compressed air and filled with an approved crack sealer. Cracks larger than 19 mm (3/4 inch) wide shall be cleaned with compressed air and filled by using a squeegee to apply a mixture of aggregate and sealer. The final surface of the filled cracks shall be flush or up to 3 mm (1/8 inch) below the pavement surface. Remove any excess materials from the pavement surface.

3.1.2 Vegetation

Remove vegetation existing in the cracks by a heat lance, sand blasting, water blasting, or a power driven brush and treat the cracks with a herbicide. The type of herbicide and method of application will require approval by the Contracting Officer.

3.1.3 Oil or Fuel Contaminated Areas

Clean grease-contaminated and oil-contaminated areas, or remove and replace with new asphalt pavement as directed by the Contracting Officer. Areas not removed shall be cleaned by scrubbing with a detergent and flushing with water. Areas, which cannot be satisfactorily cleaned by this manner, may be primed with material especially manufactured to provide a surface suitable for sealing.

3.1.4 Tack Coat

Prepare the pavement surface as specified above and spray it with a thin coat of 3 parts water to 1 part coal-tar emulsion. Apply the tack coat at a rate of 0.23 to 0.45 L/square meter (0.05 to 0.10 gallons/square yard).

3.2 MIXING AND APPLICATION OF SEALER

3.2.1 Mixing

3.2.1.1 Mechanical Mixing

Mix the sealer as described in paragraph EQUIPMENT. The sealer mixture shall be of the desired consistency with no segregation when deposited on the surface of the pavement. Provide the sealer mixture with no signs of uncoated aggregate, segregation, or premature breaking of the emulsion when applied to the pavement surface.

3.2.1.2 Hand Mixing

Where small amounts of sealer are required, making mechanical mixing uneconomical, mixing may be accomplished by hand. The preparation requirements are the same as given in the preceding paragraph for mechanical mixing.

3.2.2 Mechanical Application

3.2.2.1 Squeegee

Feed sufficient quantities of the sealer mixture into the spreader to obtain uniform and complete pavement coverage. Operate the spreader at such a forward speed that the amount of sealer mixture in the spreader remains essentially constant. Apply the sealer in such a manner that the minimum thickness will equal that given in Table I. Apply a minimum of two coats with aggregate at the minimum application rate consistent with the size of the aggregate used. Thoroughly cure each application before another application is placed. Do not allow oversized aggregate particles in the sealer mixture; no buildup of cured sealer mixture shall be allowed to collect in the spreader. Do not leave streaks in the finished surface.

3.2.2.2 Spray

If the sealer is applied by spraying, provide a coating thickness equal to that required for squeegee application. Apply the sealer in at least two coatings. Variation in the specified rate shall not vary by more than plus or minus 5 percent. Thoroughly cure each coating before another coating is applied.

3.2.3 Hand Application

Areas which cannot be reached with the application equipment, or areas with minor defects shall have the sealers applied with hand squeegees or sprayed by the wand to provide complete and uniform coverage. Tack and fog these areas, as required, prior to placing sealer by hand.

3.2.4 Wetting Pavement Surface

Immediately prior to application of the sealer mixture, moisten the surface of the pavement with a fog spray of water from the spray bar on the sealer machine. Do not allow free water on the surface of the pavement following the fog spray. Adjust the rate of application of the fog spray during the day to suit pavement temperature, surface texture, humidity, and dryness of the pavement surface.

3.2.5 Joints

Longitudinal joint between adjacent lanes shall have no visible overlaps, pinholes, or uncovered areas. Smooth immediately with hand squeegees thick spots caused by overlapping before the sealer mixture cures. Overlaps, which occur at transverse joints, shall also be smoothed before the sealer mixture cures, so that a uniform surface is obtained which contains no breaks or discontinuities. Joints should be made while the first coat is still workable. If fresh working is not possible, the previous coat shall be cured sufficiently to support the spreader box.

3.3 CURING

Protect sealed pavement from traffic by barricades and markers until the seal has cured a minimum of 12 hours, unless otherwise indicated. Repair, at no cost to the Government, areas damaged by traffic or from the effects of adverse weather conditions.

3.4 RETEST AND REJECTION

If the results of any test do not conform to the requirements of this specification, reject the sealer. Retesting of nonconforming materials or new materials shall be at the Contractor's expense and at the Contracting Officer's discretion.

3.5 CLEANUP

Upon completion of work, collect and remove from the site all trash, discarded seal material, or other refuse and dispose of it as approved by the Contracting Officer.

-- End of Section --

SECTION 32 13 11

CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306R	(2010) Guide to Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A1064/A1064M	(2013) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A184/A184M	(2006; E2011) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A996/A996M	(2009b) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing

	Concrete
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2014) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2012) Standard Test Method for Lightweight Particles in Aggregate
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2013a) Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1646/C1646M	(2008a) Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C174/C174M	(2013) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192/C192M	(2014) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C294	(2012) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C295/C295M	(2012) Petrographic Examination of Aggregates for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2014a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2003; R 2008) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C78/C78M	(2012; E 2013) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C881/C881M	(2013) Standard Specification for Epoxy-Resin-Base Bonding Systems for

	Concrete
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2013) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D3665	(2012) Random Sampling of Construction Materials
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM E1274	(2003; R 2012) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2011) Steel Bars for Concrete Reinforcement
KS D 3629	(2005) Fusion Bonded Epoxy Coated Reinforcing Steel Bars
KS D 7017	(2007) Welded Steel Wire Fabrics
KS F 2309	(2009) Standard test method for amount of material in passing standard sieve 0.075mm in soils
KS F 2325	(2002) Testing method for flexural strength of soil-cement using simple beam with third point loading
KS F 2401	(2007) Method of Sampling Fresh Concrete
KS F 2402	(2007) Slump of Concrete
KS F 2405	(2010) Compressive Strength of Concrete

KS F 2408	(2000) Method of test for flexural strength of concrete
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2501	(2007) Sampling Aggregate
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2507	(2007) Method of test for soundness of aggregates by use of sodium sulfate
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine
KS F 2513	(2002) Testing method for lightweight pieces in aggregate
KS F 2526	(2007) Aggregate for Concrete
KS F 2538	(2005) Specification for preformed expansion joint fillers for concrete paving and structural construction
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 2575	(2013) Testing method for flat or elongated particles in coarse aggregate
KS F 4009	(2011) Ready-Mixed Concrete
KS L 5201	(2013) Portland Cement

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2011) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2002) Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine

	Aggregate
COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 662	(2009) Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

1.2 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, the construction at each interface shall conform to the requirements of both this section and the other section, including tolerances for both.

1.2.1 Surface Smoothness

Use the profilograph method for all longitudinal testing, except for paving lanes less than 60 m (200 feet) in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 60 m (200 feet), within 60 m (200 feet) on both the approach and departure sides of an aircraft arresting gear, and at the ends of the paving limits for the project. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.) or existing rough or high PI pavement, finish the surface to meet the approval of the Contracting Officer. Detailed notes shall be kept of the results of the testing and a copy furnished to the Government after each day's testing.

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 6 mm (1/4 inch) or more, and all pavements shall be within the limits specified when checked with an approved 4 m (12 feet) straightedge. Runways and taxiways shall have a variation from the specified straight edge not greater than 3 mm (1/8 inch) in the longitudinal direction and not greater than 6 mm (1/4 inch) in the transverse direction. Runway pavement within 60 m (200 feet) on both the approach and departure sides of an aircraft arresting gear shall have a variation in the longitudinal direction from the specified straightedge not more than plus or minus 3 mm (1/8 inch). All other airfield areas shall have a variation from a straight edge not greater than 6 mm (1/4 inch) in either the longitudinal or transverse direction.Roads, streets, tank hardstands, vehicular parking areas, and open storage areas shall have a variation from the specified straight edge not greater than 6mm (1/4 inch) in either the longitudinal or transverse direction.

b. Profilograph Testing: The finished surfaces of the pavements shall have no abrupt change of 6 mm (1/4 inch) or more, and each 0.1 km (0.1 mile) segment of each pavement lot shall have a Profile Index not greater than specified when tested with an approved California-type profilograph. Runways and taxiways shall have a Profile index not greater than 110 mm per km (7 inches per mile) in the longitudinal direction. Runway and taxiway transverse smoothness shall be measured with the straight edge method and the straight edge requirements shall apply. All other airfield areas shall have a Profile Index not greater than 140 mm per km (9 inches per mile) in the longitudinal direction.Roads, streets, tank hardstands, vehicular parking areas and open storage areas shall have a Profile index not greater than 140 mm per km (9 inches per mile) in the longitudinal direction.

c. Bumps ("Must Grind" Areas): Any bumps ("must grind" areas) shown on the profilograph trace which exceed 10 mm (0.4 inch) in height shall be reduced by diamond grinding in accordance with subparagraph "Diamond Grinding of PCC Surfaces" below until they do not exceed 7.5 mm (0.3 inch) when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding.

d. Testing Method: After the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement, test the entire surface of the pavement in each lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. If any pavement areas are ground, these areas shall be retested immediately after diamond grinding. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines. The transverse lines shall be 4.5 m (15 feet) or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane shown on the drawings, regardless of whether the Contractor is allowed to pave two lanes at a time, and at the 1/8th point in from each side of the lane. Other areas having obvious deviations shall also be tested. Longitudinal testing lines shall be continuous across all joints. Transverse testing lines for pilot lanes shall be carried to construction joint lines and for fill-in lanes shall be carried 600 mm (24 inches) across construction joints, and the readings in this area applied to the fill-in lane. Straightedge testing of the longitudinal edges of slipformed pilot lanes shall also be performed before paving fill-in lanes as specified below.

(1) Straightedge Testing: The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Measurements shall be determined along the entire length of the straight edge.

(2) Profilograph Testing: Perform profilograph testing using approved California profilograph and procedures described in ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each 0.1 km (0.1 mile) segment of the pavement lot. Grade breaks on aprons parking lots shall be accommodated by breaking the profile segment into short sections and repositioning the blanking band on each section. The "blanking band" shall be 5 mm (0.2 inch) wide and the "bump template" shall span 25 mm (1 inch) with an offset of 10 mm (0.4

inch). The profilograph testing of the last 9.1 m (30 feet) of a paving lane in the longitudinal direction from each day's paving operation shall be counted on the following day's continuation lane. The profile index shall be computed for each pass of the profilograph (3 per lane) in each 0.1 km (0.1 mile) segment. The profile index for each segment shall be the average of the profile indices for each pass in each segment. Profilographs of unequal lengths shall be scaled and proportioned to an equivalent 0.1 km (0.1 mile) as outlined in the CTM 526. A copy of the reduced tapes shall be furnished the Government at the end of each day's testing.

1.2.2 Edge Slump and Joint Face Deformation

a. Edge Slump: When slip-form paving is used, not more than 15.0 percent of the total free edge of each pavement panel shall have an edge slump exceeding 6 mm (1/4 inch) and none of the free edge of the pavement lot shall have an edge slump exceeding 9 mm (3/8 inch). (A pavement panel is defined as a lane width by the length between two adjacent transverse contraction joints. The total free edge of the pavement will be considered to be the cumulative total linear measurement of pavement panel edge originally constructed as non-adjacent to any existing pavement; i.e., 30 m (100 feet) of pilot lane originally constructed as a separate lane, will have 60 m (200 feet) of free edge; 30 m (100 feet) of fill-in lane will have no free edge, etc.,). The area affected by the downward movement of the concrete along the pavement edge shall not exceed 450 mm (18 inches) back from the edge.

b. Joint Face Deformation: In addition to the edge slump limits specified above, the vertical joint face shall have a surface within the maximum limits shown below:

Offset from Straightedge Applied Logintudinally to Pavement Surface	Offset from Straightedge Applied Longitudinally to Vertical Face	Offset from Straightedge Applied Top to Bottom Against the Joint Face	Abrupt Offset in Any Direction	Offset of Joint Face from True Vertical
Airfield Pavement				
3 mm (1/8 inch)	6mm(1/4inch)	9 mm(3/8inch)	3 mm(1/8inch)	8 mm/100 mm (1 inch/12 inches)
All Other Pavement				
6 mm (1/4 inch)	All other items same as airfield pavement			

c. Slump Determination: Immediately after the concrete has hardened sufficiently to permit walking thereon, the pavement surface of each lot shall be tested by the Contractor. Testing shall be performed with a minimum 4 m (12 feet) straightedge to reveal irregularities exceeding the edge slump tolerance specified above. The vertical edge slump shall be determined at each free edge of each slipformed paving lane constructed. The straightedge shall be placed transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Measurements shall be made at 1.5 to 4.5 m (5 to 15 feet) spacings, as directed, commencing at the header where paving was started. Initially measurements shall be made at 1.5 m (5 feet) intervals in each lane. When no deficiencies are present, the Contracting Officer may approve an increase in the interval. When any deficiencies exist, the interval will be returned to 1.5 m (5 feet). In no case shall the interval exceed 4.5 m (15 feet). In addition to the transverse edge slump determination above, the Contractor, at the same time, shall check the longitudinal surface smoothness of the joint on a continuous line 25 mm (1 inch) back from the joint line using the 4 m (12 feet) straightedge advanced one-half its length for each reading. Other tests of the exposed joint face shall be made to ensure that a uniform, true vertical joint face is attained. The measurements shall be made by the Contractor, shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Contracting Officer within 24 hours after measurement is made. The report shall also identify areas requiring replacement.

d. Excessive Edge Slump: When edge slump exceeding the limits specified above is encountered on either side of the paving lane, additional straightedge measurements shall be made, if required, to define the linear limits of the excessive slump. The concrete slabs having excessive edge slump or joint deformation shall be removed and replaced to the next transverse joint in conformance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Use of slip-form paving equipment and procedures that fail to consistently provide edges within the specified tolerances on edge slump and joint face deformation shall be discontinued and the pavements shall be constructed by means of standard paving procedures using fixed forms.

1.2.3 Plan Grade

Within 5 days after paving of each lot, the finished surface of the pavement area shall be tested, by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. The results of this survey shall be recorded and a copy given to the Government at the completion of the survey of each lot. The finished surfaces of airfield runway, taxiway, and apron pavements shall vary not more than 13 mm (1/2 inch) above or below the plan grade line or elevation indicated. The surfaces of other pavements shall vary not more than 19 mm (3/4 inch). The above deviations from the approved grade line and elevation will not be permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. The finished surfaces of new abutting pavements shall coincide at their juncture.

1.2.4 Flexural Strength

Submit certified copies of laboratory test reports and sources for cement, supplementary cementitious materials (SCM), aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this project. All aggregate tests shall have been performed no earlier than 6 months prior to contract award. Each lot of pavement will be evaluated for acceptance in accordance with the following procedures.

a. Sampling and Testing: For acceptance, one composite sample of concrete from each sublot shall be obtained in accordance with ASTM C172/C172M or KS F 2401 from one batch or truckload. Test cylinders 152 x 305 mm (6 x 12 inches) shall be fabricated and cured in accordance with ASTM C31/C31M, and tested in accordance with ASTM C39/C39M or KS F 2405

Test two test cylinders per sublot (8 per lot) at 14 days. Test beams 152 x 152 mm (6 x 6 inches) shall be fabricated and cured in accordance with ASTM C31/C31M; and tested in accordance with ASTM C78/C78M or KS F 2325.

b. Computations: Average the eight 14-day strength tests for the lot. The average strength shall be used in accordance with paragraph "Concrete Strength for Final Acceptance" in PART 2.

1.2.5 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Two cores, between 100 and 150 mm (4 and 6 inches) in diameter, shall be drilled from the pavement, per sublot (8 per lot). The Contractor is responsible for drilling the cores within 3 days after lot placement, filling the core holes with an approved non-shrink concrete, respraying the cored areas with curing compound, and for measuring the cores. Each core shall be inspected for voids, thickness of paste on the surface, and depth of reinforcement (if required). Provide the results with the thickness measurement data. Eight measurements of thickness shall be made around the circumference of each core and one in the center, in accordance with ASTM C174/C174M, using calibrated calipers for specimens longer than 250 mm (10 inches). The pavement thickness from the 8 cores for the lot shall be averaged and shall be evaluated as described in paragraph: PAYMENT ADJUSTMENT FOR THICKNESS above.

1.2.6 Diamond Grinding of PCC Surfaces

In areas not meeting the specified limits for surface smoothness and plan grade, high areas shall be reduced to attain the required smoothness and grade, except as depth is limited below. High areas shall be reduced by grinding the hardened concrete with an approved diamond grinding machine after the concrete is 14 days or more old. Grinding shall be accomplished by sawing with an industrial diamond abrasive which is impregnated in the saw blades. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the concrete pavement or joint faces. The saw blades shall be 3 mm (1/8-inch) wide and there shall be a minimum of 55 to 60 blades per 300 mm (12 inches) of cutting head width depending on the hardness of the aggregate. Each machine shall be capable of cutting a path 0.9 to 1.2 m (3 to 4 feet) wide. Grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by grinding the surface of the hardened concrete shall not exceed 10 percent of the total area of any sublot. The depth of diamond grinding shall not exceed 6 mm (1/4 inch). All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, shall be removed and replaced in conformance with paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. In pavement areas given a wire comb or tined texture, areas exceeding 2 square meters (25 square feet) that have been corrected by diamond grinding shall be retextured by transverse grooving using an approved grooving machine of standard manufacture. The grooves shall be 6 mm (1/4 inch) deep by 6 mm (1/4 inch) wide on 37 mm (1-1/2 inch) centers and shall be carried into, and tapered to zero depth within the non-corrected surface, or shall match any existing grooves in the adjacent pavement. All areas in which diamond grinding has been performed will be subject to the thickness tolerances specified in paragraph: Thickness, above.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment
Proposed Techniques; G
Dowels; G
Dowel Bar Assemblies; G

SD-05 Design Data

Proportioning Studies; G, ED

SD-06 Test Reports

Sampling and Testing; G, ED

SD-07 Certificates

Contractor Quality Control Staff; G, ED
Laboratory Accreditation; G, ED
NRMCA Certificate of Conformance; G, ED
Commercial Laboratory; G, ED

1.4 QUALITY ASSURANCE

1.4.1 Contractor Quality Control Staff

Submit American Concrete Institute certification for Contractor Quality Control staff. Qualifications and resumes for petrographer, surveyor, concrete batch plant operator, and profilograph operator. All Contractor Quality Control personnel assigned to concrete construction shall be American Concrete Institute (ACI) certified in the following grade (or shall have written evidence acceptable to the Contracting Officer's representative of having completed similar qualification programs):

a. CQC personnel responsible for inspection of concrete paving operations: ACI Concrete Transportation Inspector.

b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Concrete Flatwork Technician/Finisher.

c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

d. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

If the Quality Control personnel is not certified for grades listed above, he or she shall be verified expertise to perform the control of concrete quality process properly by the Contracting Officer. And he or she shall be certified from Human Resources Development Service of Korea (HRD Korea) as Craftsman Concrete or Craftsman Construction Material Testing.

1.4.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious materials and tests identified in this specification. Resume shall detail the education, training and experience related to the project-specific test methods and deleterious materials and shall be submitted at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: All survey work shall be performed under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification at the Plant Operator level or approved equivalent by the Contracting Officer.

d. Profilograph Operator: Certification by equipment manufacturer or a state Department of Transportation.

1.4.3 Laboratory Accreditation

Laboratory and testing facilities shall be provided by and at the expense of the Contractor. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C1077, including all applicable test procedures. The laboratories performing the tests shall be accredited in accordance with ASTM C1077, including ASTM C78/C78M or KS F 2408 and ASTM C1260. The accreditation shall be current and shall include the required and optional test methods, as specified throughout this Section. Onsite temperature-controlled concrete curing facilities shall be provided.

a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies shall be performed by a commercial laboratory.

b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Steel molds shall be used for molding the beam specimens. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by ASTM C31/C31M. Flexural loading equipment shall be in accordance with ASTM C78/C78M or KS F 2408.

c. Contractor Quality Control: All sampling and testing shall be performed by an approved, onsite, independent, commercial laboratory, or for cementitious materials and admixtures, the manufacturer's laboratory. Submit USACE validation letter for commercial laboratory.

d. Laboratory Inspection: The Government will inspect the laboratory equipment and test procedures prior to the start of concreting operations for conformance to ASTM C1077. The laboratory shall maintain this certification for the duration of the project.

1.4.4 Preconstruction Testing of Materials

All sampling and testing shall be performed by, and at the expense of, the Contractor. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. No material shall be used until notice of acceptance has been given. The Contractor will not be entitled to any additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required. Additional tests may be performed by the Government at the discretion of the Contracting Officer; such Government testing will not relieve the Contractor of any testing responsibilities.

1.4.4.1 Aggregates

Aggregates shall be sampled in the presence of a Government Representative. Samples shall be obtained in accordance with ASTM D75/D75M or KS F 2501 and shall be representative of the materials to be used for the project. Test results shall be submitted 7 days before commencing mixture proportioning studies.

1.4.4.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project. Test results shall be not more than 6 months old prior to use in the work. Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing will be retested at the expense of the Contractor and will be rejected if test results are not satisfactory.

1.4.4.3 Cementitious Materials

Cement, ground granulated blast furnace (GGBF) slag, and pozzolan will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is furnished. Mill test reports shall be no more than 1 month old, prior to use in the work. No cementitious material shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious material may be subjected to testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious material that has not been used within 6 months after testing shall be retested at the Contractor's expense and shall be rejected if test results are not satisfactory.

1.4.5 Testing During Construction

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials, and concrete as specified herein. The Government will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Government will in no way relieve the Contractor of the specified testing requirements.

1.4.6 Test Section

Up to 10 days, but not more than 60 days, prior to construction of the concrete pavement, construct a test section near the job site, but not as part of the production pavement area. Use the test section to develop and demonstrate to the satisfaction of the Contracting Officer the proposed techniques of mixing, hauling, placing, consolidating, finishing, curing, initial saw cutting, start-up procedures, testing methods, plant operations, and the preparation of the construction joints. Variations in mixture proportions, other than water, shall be made if directed. Vary the water content, as necessary, to arrive at the appropriate content. The mixing plant shall be operated and calibrated prior to start of placing the test section. Use the same equipment, materials, and construction techniques on the test section as will be used in all subsequent work. Base course preparation, concrete production, placing, consolidating, curing, construction of joints, and all testing shall be in accordance with applicable provisions of this specification. Three days after completion of the test section, provide eight cores at least 150 mm (6 inches) diameter by full depth cut from points selected in the test section by the Government. The cores will be evaluated for homogeneity, consolidation and segregation. Construct the test section meeting all specification requirements and being acceptable to the Contracting Officer in all aspects, including surface texture. Failure to construct an acceptable test section will necessitate construction of additional test sections at no additional cost to the Government. Test sections allowed to be constructed as part of the production paving which do not meet specification requirements shall be removed at the Contractor's expense. If the Contractor proposes to use slipform paving and is unable to construct an acceptable test section, the slipform paving equipment shall be removed from the job and the construction completed using stationary side forms and equipment compatible with them. Production paving shall not commence until the results on aggregates and concrete, including evaluation of the cores, and all pavement measurements for edge slump, joint face deformation, actual plan grade, surface smoothness and thickness have been submitted and approved by the Contracting Officer. Pavement accepted as a production lot will be evaluated and paid in accordance with Paragraph: ACCEPTABILITY OF WORK below.

1.4.6.1 Pilot Lane

The test section shall consist of one paving lane at least 130 m (400 feet) long and shall be constructed to the same thickness as the thickest portion of pavement shown on the Drawings. The lane width shall be the same as that required for use in the project. The test section shall contain at least one transverse construction joint. If keyed or doweled longitudinal construction joints are required in any of the production pavements, they shall be installed full length along one side of the test strip throughout the test section. If both keys and dowels are required, each shall be installed in half of the test section. Two separate days shall be used for construction of the test section.

1.4.6.2 Fill-In Lane

The first 130 m (400 feet) of the initial production fill-in lane shall be considered a fill-in lane test section for purposes of testing and evaluation. All requirements for the test section are applicable, as appropriate. Obtain cores from the fill-lane lane side of the longitudinal construction joint with the pilot lane. The cores will be evaluated for homogeneity, consolidation, and segregation.

1.4.7 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of tests made by the Government or by the Contractor's approved commercial laboratory or the supplier's approved laboratory, all as specified herein. The Government may make check tests to validate the results of the Contractor's testing. If the results of the Contractor tests vary by less than 2.0 percent of the Government's test results, the results of the Contractor's tests will be used. If the results of the Government and Contractor tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, each sampling and testing procedure shall be carefully evaluated and both the Government and the Contractor shall take another series of tests on duplicate samples of material. If these vary by 4.0 percent or more, the results of the tests made by the Government shall be used and the Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government will in no way at any time relieve the Contractor from the specified testing requirements.

1.4.8 Acceptance Requirements

1.4.8.1 Pavement Lots

A lot will be that quantity of construction that will be evaluated for acceptance with specification requirements. A lot will be equal to one shift of production not to exceed 750 cubic meters (1,000 cubic yards). In order to evaluate thickness, each lot will be divided into four equal sublots. Grade determinations will be made on the lot as a whole. Surface smoothness determinations will be made on every 0.1 km (0.1 mile) segment in each lot. Location of all samples shall be selected on a random basis in accordance with ASTM D3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, the following procedure shall be used to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they shall constitute a lot. Where one or two sublots have been completed, they shall be incorporated into the next lot (except for the last lot), and the total number of sublots shall be used and acceptance criteria adjusted accordingly.

1.4.8.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment at the Contractor's expense. Individuals performing sampling, testing and inspection duties shall meet the required Qualifications. The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas will be in addition to the sublot or lot testing, and the requirements for these areas will be the same as those for a sublot or lot. Provide facilities for and, where directed, personnel to assist in obtaining samples for any Government testing.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Bulk Cementitious Materials

Furnish all cementitious material in bulk. The temperature of the cementitious material, as delivered to storage at the site, shall not exceed 65 degrees C (150 degrees F). Sufficient cementitious materials shall be in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.5.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Each size of aggregate from each source shall be stored separately in free-draining stockpiles. Aggregate stored on ground shall have a minimum 0.6 m (24 inches) thick sacrificial layer left undisturbed. Fine aggregate and the smallest size coarse aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient aggregate shall be maintained at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Tracked equipment shall not be allowed on coarse aggregate stockpiles.

1.5.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. All materials shall be stored avoiding contamination and deterioration.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious materials shall be portland cement, blended cement or only portland cement in combination with supplementary cementitious materials (SCM), and shall conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.1.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type I II V or KS L 5201, Class I II V, low alkali including false set requirements low alkali including false set requirements if the ASTM C1260 of any aggregate exceeds 0.04% expansion. Type III cement shall be used only in concrete with Contracting Officer's approval.

2.1.2 Blended Cements

Blended cement shall conform to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion and sulfate soundness. The pozzolan added to the Type IP blend shall be ASTM C618 Class F or Class N and shall be interground with the cement clinker. The manufacturer shall state in writing that the amount of pozzolan in the finished cement will not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend shall not change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of Table 2 in paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT do not apply to the SCM content of blended cement.

2.1.3 Pozzolan

2.1.3.1 Fly Ash

Fly ash shall conform to ASTM C618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 3 percent. Class F fly ash for use in mitigating Alkali-Silica Reactivity shall have a total equivalent alkali content less than 3 percent.

2.1.3.2 Raw or Calcined Natural Pozzolan

Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 3 percent. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total equivalent alkali content less than 3 percent.

2.1.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) shall conform to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age shall be at least 95 percent of the control specimens.

b. The average particle size shall not exceed 6 microns.

2.1.4 Ground Granulated Blast-Furnace (GGBF) Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C989/C989M, Grade 100 or Grade 120.

2.1.5 Supplementary Cementitious Materials (SCM) Content

The Contractor may elect to use one of the SCMs listed below, unless the SCM is required to mitigate ASR.

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
$SiO_2 + Al_2O_3 + Fe_2O_3 > 70$ percent	25	35
$SiO_2 + Al_2O_3 + Fe_2O_3 > 80$ percent	20	35
$SiO_2 + Al_2O_3 + Fe_2O_3 > 90$ percent	15	35
UFFA and UFP	7	16

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
GGBF Slag	40	50

2.2 AGGREGATES

2.2.1 Aggregate Sources

2.2.1.1 Durability

Aggregate shall have a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. The service record shall include a condition survey of the existing concrete and a review of the concrete-making materials, including coarse and fine aggregates, cement, and mineral admixtures. This review should consider the previous aggregate source and test results, cement mill certificate data, mineral admixture chemical and physical composition, and the mix design (cement factor and water-cementitious material ratio). Aggregate not having a satisfactory demonstrable service record shall have a durability factor of 50 or more when subjected to freezing and thawing of specimens prepared in accordance with ASTM C1646/C1646M and tested in accordance with ASTM C666/C666M, Procedure A.

2.2.1.2 Alkali-Silica Reactivity

Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for alkali-aggregate reactivity. Both coarse aggregate size groups shall be tested.

a. The fine and coarse aggregates shall be evaluated separately, using ASTM C1260. Test results of the individual aggregates shall have a measured expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Should the test data indicate an expansion of greater than 0.08 percent, the aggregate(s) shall be rejected or additional testing shall be performed as follows: utilize the Contractor's proposed low alkali portland cement, blended cement, and/or SCM, and/or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, the testing shall be in accordance with ASTM C1567. If Lithium Nitrate is being evaluated, with or without SCMs, the testing shall be in accordance with COE CRD-C 662. Determine the quantity that will meet all the requirements of these specifications and that will lower the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Mixture proportioning shall be based on the highest percentage of SCM required to mitigate ASR-reactivity

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing to the Contracting Officer for evaluation and acceptance.

2.2.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, the combined aggregate grading shall meet the following requirements:

a. The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

b. The Coarseness Factor (CF) shall be determined from the following equation:

CF = (cumulative percent retained on the 9.5 mm sieve)(100)/(cumulative percent retained on the 2.36 mm sieve)
CF = (cumulative percent retained on the 3/8 in. sieve)(100)/(cumulative percent retained on the No. 8 sieve)

c. The Workability Factor WF is defined as the percent passing the 2.36 mm (No. 8) sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 42 kg (94 pounds) of cementitious material per cubic meters (cubic yards) greater than 335 kg per cubic meters (564 pounds per cubic yards).

d. A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.)

2.2.2 Coarse Aggregate

2.2.2.1 Material Composition

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, , or a combination thereof. Aggregate used for paving compass calibration hardstands shall be free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone.Coarse aggregate used for paving power check pads shall be limestone, dolomite, basalt or other approved low-silica content aggregate which will not cause thermal distress from jet blast. Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles meeting the requirements of ASTM C33/C33M except as specified herein. Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings. . Coarse aggregate shall not show more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131 or KS F 2508. The sodium sulfate soundness loss shall not exceed 12 percent, or the magnesium sulfate soundness loss shall not exceed 18 percent after five cycles when tested in accordance with ASTM C88 or KS F 2507.

2.2.2.2 Particle Shape Characteristics

Particles of the coarse aggregate shall be generally spherical or cubical in shape. The quantity of flat and elongated particles in any size group coarser than the 9.5 mm (3/8 inch) sieve shall not exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle

Test of ASTM D4791 or KS F 2575. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.2.2.3 Size and Grading

The nominal maximum size of the coarse aggregate shall be 37.5 mm (1.5 inch. Grade and furnish the individual aggregates in two size groups meeting the individual grading requirements of ASTM C33/C33M or KS F 2526, Size No. 4 (37 mm to 19 mm (1.5 to 0.75 inch)) and Size No. 67 (19 mm to No. 4 (0.75 inch to No. 4)) to meet the coarseness and workability factor criteria for the contractor-proposed combined gradation. A third aggregate size group may be required to meet the above mentioned coarseness and workability criteria of paragraph COMBINED AGGREGATE GRADATION.

2.2.2.4 Deleterious Materials - Airfield Pavements

The amount of deleterious material in each size group of coarse aggregate shall not exceed the limits shown in Table 5 below, determined in accordance with the test methods shown.

TABLE 5	
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS	
Percentage by Mass	
Materials (h)	Severe Weather
Clay lumps and friable particles (ASTM C142/C142M)	0.2
Shale (a) (ASTM C295/C295M)	0.1
Material finer than 0.075 mm (No. 200 sieve) (b) (ASTM C117 or KS F 2309)	0.5
Lightweight particles (c)(ASTM C123/C123M or KS F 2513)	0.2
Clay ironstone (d) (ASTM C295/C295M)	0.1
Chert and cherty stone (less than 2.40 Sp. Gr.) (e)(ASTM C123/C123M and ASTM C295/C295M)	0.1
Claystone, mudstone, and siltstone (f)(ASTM C295/C295M)	0.1
Shaly and argillaceous limestone (g) (ASTM C295/C295M)	0.2
Other soft particles (COE CRD-C 130)	1.0
Total of all deleterious substances exclusive of material finer than 0.075 mm (No. 200 sieve)	1.0
(a) Shale is defined as a fine-grained, thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.	

TABLE 5	
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS	
Percentage by Mass	
Materials (h)	Severe Weather
(b) Limit for material finer than 0.075 mm (No. 200 sieve) will be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale.	
(c) The separation medium shall have a density of Sp. Gr. of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.	
(d) Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard-shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.	
(e) Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone.	
(f) Claystone, mudstone, or siltstone, is defined as a massive fine-grained sedimentary rock that consists predominantly of indurated clay or silt without laminations or fissility. It may be indurated either by compaction or by cementation.	
(g) Shaly limestone is defined as limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).	
(h) Perform testing in accordance with the referenced test methods, except that the minimum sample size shall be as specified below.	

2.2.2.5 Testing Sequence/Deleterious Materials in Coarse Aggregate - Airfields Only

The Contractor will not be entitled to any extension of time or additional payment due to any delays caused by the testing, evaluation, or personnel requirements. The size of the coarse aggregate sample shall be at least 90 kg (200 pounds) for the 19 mm (3/4 inch) and larger maximum size and 12 kg (25 pounds) for the 4.75 to 19 mm (No. 4 to 3/4 inch) coarse aggregate and 5 kg (10 pounds) for the fine aggregate. Provide facilities for the ready procurement of representative test samples. The testing procedure on each sample of coarse aggregate for compliance with limits on deleterious materials shall be as follows:

Step 1: Wash each full sample of coarse aggregate for material finer than the 0.075 mm (No. 200) sieve. Discard material finer than the 0.075 mm (No.200) sieve.

Step 2: Test remaining full sample for clay lumps and friable particles and remove.

Step 3: Test remaining full sample for lightweight particles (Sp. Gr. 2.0) and remove.

Step 4. Test remaining full sample for chert and/or cherty stone with SSD density of less than 2.40 specific gravity. Remove lightweight chert and/or cherty stone. Restore other materials less than 2.40 to the sample.

Step 5: Test remaining sample for clay-ironstone, shale, claystone, mudstone, siltstone, shaly and/or argillaceous limestone, and remove.

Step 6: Test approximately one-fifth of remaining full sample for other soft particles.

2.2.2.6 Deleterious Material - Road Pavements

The amount of deleterious material in each size group of coarse aggregate shall not exceed the limits in the following table when tested as indicated.

LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR ROAD PAVEMENTS	
Percentage by Mass	
Clay lumps and friable particles (ASTM C142/C142M)	2.0
Material finer than 0.075 mm (No. 200 sieve) (ASTM C117)	1.0
Lightweight particles (ASTM C123/C123M)	1.0
Other soft particles (COE CRD-C 130)	2.0
Total of all deleterious substances, exclusive of material finer than 0.075 mm (No. 200 sieve)	5.0

The limit for material finer than the 0.075 mm (No. 200) sieve will be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. The separation medium for lightweight particles shall have a density of 2.0 specific gravity. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.2.3 Fine Aggregate

2.2.3.1 Composition

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles meeting the requirements of ASTM C33/C33M or KS F 2526. Aggregate used for paving compass calibration hardstands shall be free of materials having undesirable magnetic properties, including magnetite in granite, high-iron minerals in traprock, and pyrite in limestone. Each type of fine aggregate shall be stockpiled and batched separately. Particles of the fine aggregate shall be generally spherical or cubical in shape.

2.2.3.2 Grading

Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33/C33M and shall have a fineness modulus of not less than 2.50 nor more than 3.40.

2.2.3.3 Deleterious Material

Sample size for fine aggregate proposed for use in airfield paving shall be 5 kg (10 pounds). The amount of deleterious material in the fine aggregate shall not exceed the following limits by mass:

Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than 0.075 mm (No. 200 sieve) ASTM C117 or KS F 2309	3.0
Lightweight particles ASTM C123/C123M or KS F 2513 using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all above	3.0

2.3 CHEMICAL ADMIXTURES

2.3.1 General Requirements

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. The air-entraining admixture shall conform to ASTM C260/C260M or KS F 2560. An accelerator conforming to ASTM C494/C494M, Type C or KS F 2560, may be used only when specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES below and shall not be used to reduce the amount of cementitious material used. Calcium chloride and admixtures containing calcium chloride shall not be used. Retarding or water-reducing admixture shall meet the requirements of ASTM C494/C494M, Type A, B, or Dor KS F 2560, except that the 6-month and 1-year compressive strength tests are waived. ASTM C494/C494M or KS F 2560, Type F and G high range water reducing admixtures and ASTM C1017/C1017M flowable admixtures shall not be used.

2.3.2 Lithium Nitrate

The lithium admixture shall be a nominal 30 percent aqueous solution of

Lithium Nitrate, with a density of 1.2 kg/Liter (10 pounds/gallon), and shall have the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
$LiNo_3$ (Lithium Nitrate)	30 +/- 0.5
SO_4^{-2} (Sulfate Ion)	0.1 (max)
Cl^- (Chloride Ion)	0.2 (max)
Na^+ (Sodium Ion)	0.1 (max)
K^+ (Potassium Ion)	0.1 (max)

Provide a trained representative to supervise the lithium nitrate admixture dispensing and mixing operations.

2.4 MEMBRANE FORMING CURING COMPOUND

Membrane forming curing compound shall be a white pigmented compound conforming to COE CRD-C 300. conform to ASTM C309 or KS F 2540, white-pigmented Type 2, Class B.

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602/C1602M.

2.6 JOINT MATERIALS

2.6.1 Expansion Joint Material

Expansion joint filler shall be a preformed material conforming to ASTM D1751 or KS F 2538 or ASTM D1752 Type II or III. Expansion joint filler shall be 19 mm (3/4 inch) thick, unless otherwise indicated, and shall be furnished in a single full depth piece.

2.6.2 Slip Joint Material

Slip joint material shall be 6 mm (1/4 inch) thick expansion joint filler, unless otherwise indicated, conforming to paragraph: Expansion Joint Material.

2.7 REINFORCING

All reinforcement shall be free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties shall not be used.

2.7.1 Reinforcing Bars and Bar Mats

Reinforcing bars shall conform to ASTM A615/A615M, billet-steel, Grade 60 or KS D 3504. Bar mats shall conform to ASTM A184/A184M or KS D 7017. The bar members may be billet rail or axle steel.

2.7.2 Welded Wire Reinforcement

Welded Wire Reinforcement shall be deformed or smooth, conforming to ASTM A1064/A1064M, and shall be furnished in flat sheets.

2.8 DOWELS AND TIE BARS

2.8.1 Dowels

Dowels shall be single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels shall be free of loose, flaky rust and loose scale and shall be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by shearing does not exceed 1 mm (0.04 inch) on the diameter of the dowel and does not extend more than 1 mm (0.04 inch) from the end of the dowel. Dowels shall be plain (non-deformed) steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Dowel bars shall be epoxy coated in conformance with ASTM A775/A775M or KS D 3629. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.8.2 Dowel Bar Assemblies

Dowel bar assemblies shall consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. The dowels shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from rising, sliding out, or becoming distorted during paving operations.

2.8.3 Tie Bars

Tie bars shall be deformed steel bars conforming to ASTM A615/A615M, or ASTM A996/A996M or KS D 3504, Grade 60, and of the sizes and dimensions indicated. Deformed rail steel bars and high-strength billet or axle steel bars, Grade 50 or higher, shall not be used for bars that are bent and straightened during construction.

2.9 EPOXY RESIN

All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

c. Material for use for injecting cracks shall be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

2.10 EQUIPMENT

All plant, equipment, tools, and machines used in the work shall be maintained in satisfactory working conditions at all times. Submit the following:

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. Obtain National Ready Mixed Concrete Association (NRMCA) certification of the concrete plant or approved equivalent by the Contracting Officer. The concrete plant shall be inspected by the Contracting Officer. All fees and costs associated with this inspection shall be paid by the Contractor. Submit a copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist, NRMCA Certificate of Conformance, and Calibration documentation on all measuring and weighing devices prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature shall show that the equipment meets all details of these specifications. Detailed information on automatic laser controlled systems shall be submitted if proposed for use.

2.10.1 Batching and Mixing Plant (Except Remicon Plant)

a. Location: The batching and mixing plant shall be located on project site as indicated on the drawings or off Government premises no more than 15 minutes haul time from the placing site. For remicon plant, conform to requirements for Ready-Mix Concrete in Section 03 30 00 CAST-IN-PLACE CONCRETE There shall be operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

b. Type and Capacity: The batching and mixing plant shall be a stationary-type central mix plant, including permanent installations or portable/relocatable plants installed on stable foundations. The plant shall be designed and operated to produce concrete within the specified tolerances, and shall have a capacity of at least 200 cubic meters (250 cubic yards) per hour. The batching and mixing plant shall conform to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling
2. Batching Equipment
3. Central Mixer

4. Ticketing System
5. Delivery System

c. Tolerances: The following tolerances shall apply.

Materials	Percentage of Required Mass
Cementitious Materials	plus or minus 1
Aggregate	plus or minus 2
Water	plus or minus 1
Admixture	plus or minus 3

For volumetric batching equipment for water and admixtures, the above numeric tolerances shall apply to the required volume of material being batched. Concentrated admixtures shall be uniformly diluted, if necessary, to provide sufficient volume per batch to ensure that the batchers will consistently operate within the above tolerance.

d. Moisture Control: The plant shall be capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the quantities of the materials being batched. An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring of moisture in the fine aggregate. The sensing element shall be arranged so that measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.

2.10.2 Concrete Mixers

a. General: Mixers shall be stationary or truck mixers. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

b. Stationary: Stationary mixers shall be drum or pan mixers. Mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

c. Mixing Time and Uniformity for Stationary Mixers: For stationary mixers, before uniformity data are available, the mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, shall be 1 minute for mixers having a capacity of 0.75 cubic meters (1 cubic yards). For mixers of greater capacity, this minimum time shall be increased 20 seconds for each additional 1 cubic meters (1.33 cubic yards) or fraction thereof. After results of uniformity tests are available, the mixing time may be reduced to the minimum time required to meet uniformity requirements; but if uniformity requirements are not being met, the mixing time shall be increased as directed. The mixing time for full batch production shall be a minimum of 75 seconds. Mixer performance tests at new mixing times shall be performed immediately after any change in mixing time. The Regular Test sequence shall be conducted for initial determination of the mixing time or as directed. When regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements listed in Table 1 below.

d. The Abbreviated Test sequence shall be conducted for production concrete verification at the frequency specified in Table 6. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The concrete proportions used for uniformity tests shall be as used on the project. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers shall apply to the others, subject to the approval of the Contracting Officer. All mixer performance (uniformity) testing shall be performed in accordance with COE CRD-C 55 and with paragraph titled TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3.

TABLE 1 UNIFORMITY REQUIREMENTS--STATIONARY MIXERS

Parameter	Regular Tests Allowable Maximum Range for Average of 3 Batches	Abbreviated Tests Allowable Maximum Range for 1 Batch
Unit weight of air-free mortar	32 kg/cubic meters (2.0 lbs/cubic feet)	32 kg/cubic meters (2.0 lbs/cubic feet)
Air content	1.0 percent	--
Slump	25 mm (1.0 inch)	25 mm (1.0 inch)
Coarse aggregate	6.0 percent	6.0 percent
Compressive strength at 7 days	10.0 percent	10.0 percent
Water content	1.5 percent	

e. Truck: Truck mixers shall not be used for mixing or transporting slipformed paving concrete. The only truck mixers used for mixing or transporting paving concrete shall be those designed with extra large blading and rear opening specifically for low-slump paving concrete. Truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof shall conform to the requirements of ASTM C94/C94M or KS F 4009. The number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete shall be determined by uniformity tests as specified in ASTM C94/C94M and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, the mixer shall not be used until the condition is corrected. Water shall not be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Water shall be injected into the head of the mixer (end opposite the discharge opening) drum under pressure, and the drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed. Water shall not be added to the batch at any later time. Mixer performance (uniformity) tests for truck mixers shall be made in accordance with ASTM C94/C94M.

2.10.3 Transporting Equipment

Slipform concrete shall be transported to the paving site in nonagitating equipment conforming to ASTM C94/C94M or KS F 4009 or in approved agitators. Fixed form concrete shall be transported in approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. All transporting equipment shall be designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.10.4 Transfer and Spreading Equipment

Equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will transfer and spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

2.10.5 Paver-Finisher

The following items a through e apply to both fixed-form and slip-form paver-finishers. Item f is applicable to fixed-form paver-finishers and item g is applicable to slip-form paver-finishers.

a. General: The paver-finisher shall be a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement. The paver-finisher shall weigh at least 3280 kg/meter (2200 lb/feet) of lane width, and shall be powered by an engine having at least 15,000 W/meter (6.0 horsepower/feet) of lane width. The paver-finisher shall spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for forming the pavement shall be easily adjustable in width and thickness and for required crown. In addition to other spreaders required by paragraph above, the paver-finisher shall be equipped with a full width knock-down auger or paddle mechanism, capable of operating in both directions, which will evenly spread the fresh concrete in front of the screed or extrusion plate.

b. Vibrators: Immersion vibrators shall be gang mounted at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. The vibrators shall be automatically controlled so that they will be immediately stopped as forward motion of the paver ceases. The spacing of the immersion vibrators across the paving lane shall be as necessary to properly consolidate the concrete, but the clear distance between vibrators shall not exceed 750 mm (30 inches). The outside vibrators shall not be more than 300 mm (12 inches) from the lane edge. Spud vibrators shall operate at a frequency of not less than 135 Hz (8,000 impulses/minute) and an amplitude of not less than 0.75 mm (0.03 inch), as determined by COE CRD-C 521.

c. Screed or Extrusion Plate: The paver-finisher shall be equipped with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface and shall so finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. The screed or extrusion plate shall be constructed to provide adjustment for crown in the pavement. The entire machine shall provide adjustment for variation in lane width or thickness and to prevent more than 200 mm (8 inches) of the screed or extrusion plate extending over previously placed concrete on either end when paving fill-in lanes. Machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures shall be replaced as directed.

d. Longitudinal Mechanical Float: A longitudinal mechanical float may be used. If used, the float shall be specially designed and manufactured to smooth and finish the pavement surface without working excess paste to the surface. It shall be rigidly attached to the rear of the paver-finisher or to a separate self-propelled frame spanning the paving lane. The float plate shall be at least 1.5 m (5 feet) long by 200 mm (8 inches) wide and shall automatically be oscillated in the longitudinal direction while slowly moving from edge to edge of the paving lane, with the float plate in contact with the surface at all times.

e. Other Types of Finishing Equipment: Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Contracting Officer's approval. Bridge deck finishers shall have a minimum operating weight of 3400 kg (7500 pounds) and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

f. Fixed Forms: The paver-finisher shall be equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. Paver-finishers traveling on guide rails located outside the paving lane shall be equipped with wheels when traveling on new or existing concrete to remain.

g. Slipform: The slipform paver-finisher shall be automatically controlled and crawler mounted with padded tracks so as to be completely stable under all operating conditions. The paver-finisher shall finish the surface and edges so that no edge slump beyond allowable tolerance occurs. Suitable moving side forms shall be provided that are adjustable and will produce smooth, even edges, perpendicular to the top surface and meeting specification requirements for alignment and freedom from edge slump.

2.10.6 Curing Equipment

Equipment for applying membrane-forming curing compound shall be mounted on a self-propelled frame that spans the paving lane. The reservoir for curing compound shall be constantly mechanically (not air) agitated during operation and shall contain means for completely draining the reservoir. The spraying system shall consist of a mechanically powered pump which will maintain constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to give uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. All spray nozzles shall be protected with wind screens. Calibrate the spraying system in accordance with ASTM D2995, Method A, for the rate of application required in paragraph: Membrane Curing. Any hand-operated sprayers allowed by that paragraph shall be compressed air supplied by a mechanical air compressor. If the curing equipment fails to apply an even coating of compound at the specified rate, it shall immediately be replaced.

2.10.7 Texturing Equipment

a. General: Texturing equipment shall be as specified below. Before use, the texturing equipment shall be demonstrated on a test section, and the equipment shall be modified as necessary to produce the texture directed.

b. Burlap Drag: A burlap drag shall be securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Length of the material shall provide 600 to 900 mm (24 to 36 inches) dragging flat on the pavement surface. Width shall be at least equal to the width of the slab. The material shall be clean, reasonably new burlap, completely saturated with water before attachment to the frame, always resaturated before start of use, and kept clean and saturated during use. Burlap shall conform to AASHTO M 182, Class 3 or 4.

c. Broom: Surface texture shall be applied using an approved mechanical stiff bristle broom drag of a type that will uniformly score the surface transverse to the pavement center line. The broom shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. The scores shall be uniform in appearance and approximately 1.5 mm (1/16 inch) in depth but not more than 3 mm (1/8 inch) in depth.

d. Artificial Turf: The artificial turf drag shall be full-width and the leading transverse edge shall be securely fastened to a lightweight pole on a traveling bridge. At least 600 mm (2 feet) of the artificial turf shall be in contact with the concrete surface during texturing operations. The corrugations shall be uniform in appearance and approximately 2 mm (1/16 inch) in depth. A variety of different types of artificial turf are available and approval of any one type will be done only after it has been demonstrated by the Contractor to provide a satisfactory texture. One type that has provided satisfactory texture consists of 7,200 approximately 0.85-inches-long polyethylene turf blades per square foot.

e. Deep Texturing Equipment: Texturing equipment shall consist of a stiff bristled broom or a comb with spring wire tines or spring strips which will produce true, even grooves forming a drag at least 1.2 m (4 feet) long. This drag shall be mounted in a wheeled frame spanning the paving lane and so constructed that the drag is mechanically pulled in a straight line across the paving lane perpendicular to the centerline.

2.10.8 Sawing Equipment

Equipment for sawing joints and for other similar sawing of concrete shall be standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Blades shall be diamond tipped. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. Wheel saws used in the removal of concrete shall be saws with large diameter tungsten carbide tipped blades mounted on a heavy-duty chassis which will produce a saw kerf at least 40 mm (1-1/2 inch) wide. All saws shall be capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval of the Contracting Officer. No change to the initial sawcut depth shall be permitted.

2.10.9 Straightedge

Furnish and maintain at the job site, in good condition, one 4 m (12 feet) straightedge for each paving train for testing the hardened portland cement concrete surfaces. These straightedges shall be constructed of aluminum or magnesium alloy and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges shall have handles for operation on the pavement.

2.11 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.11.1 Specified Flexural Strength

Specified flexural strength, R, for concrete is 4.5 MPa (650 psi) at 28 90 days, as determined by tests made in accordance with ASTM C78/C78M of beams fabricated and cured in accordance with ASTM C192/C192M equivalent flexural strength, as specified in paragraph: Mixture Proportioning for Flexural Strength below. Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1. The concrete shall be air-entrained with a total air content of 6 plus or minus 1.5 percentage points, at the point of placement. Air content shall be determined in accordance with ASTM C231/C231M or KS F 2421. The maximum allowable slump of the concrete at the point of placement shall be 50 mm (2 inches) for pavement constructed with fixed forms. For slipformed pavement, at the start of the project, select a maximum allowable slump which will produce in-place pavement meeting the specified tolerances for control of edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

2.11.2 Concrete Temperature

The temperature of the concrete as delivered shall conform to the requirements of paragraphs, Paving in Hot Weather and Paving in Cold Weather, in PART 3. Temperature of concrete shall be determined in accordance with ASTM C1064/C1064M.

2.11.3 Concrete Strength for Final Acceptance

The strength of the concrete will be considered acceptable when the average equivalent 90-day 28-day flexural strengths for each lot are above the 'Specified Flexural Strength' as determined by correlation with 14-day compressive strength tests specified in paragraph: "Mixture Proportioning for Flexural Strength" below, The strength of the concrete will be considered acceptable when the equivalent 90-day 28-day flexural strengths for each lot are above the'Specified Flexural Strength' as determined by correlation with 14-day flexural strength tests specified in paragraph: "Mixture Proportioning for Flexural Strength" below, and no individual set (2 specimens per sublot) in the lot are 170 kPa (25 psi) or more below the equivalent 'Specified Flexural Strength'. If any lot or sublot, respectively, fails to meet the above criteria, the lot or sublot shall be removed and replaced at no additional cost to the Government. This is in addition to and does not replace the average strength required for day-to-day CQC operations as specified in paragraph: Average CQC Flexural Strength Required for Mixtures, below.

2.12 MIXTURE PROPORTIONS

2.12.1 Composition

Concrete shall be composed of cementitious material, water, fine and coarse aggregates, and admixtures. Supplementary Cementitious Materials (SCM) choice and usage shall be in accordance with paragraph: Supplementary Cementitious Materials (SCM) Content. The total cementitious material content shall be at least 280 kg/cubic meters (470 lb/cubic yards) . Admixtures shall consist of air entraining admixture and may also include, as approved, accelerator or retarder or water-reducing admixture.

2.12.2 Proportioning Studies

Trial design batches, mixture proportioning studies, and testing requirements are the responsibility of the Contractor. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. The results shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a 1 cubic meters (1 cubic yards) basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in ACI 211.1, modified as necessary to accommodate flexural strength. Submit test results including:

a. Coarse and fine aggregate gradations and plots.
b. Combined aggregate gradation and coarseness/workability plots.
c. Coarse aggregate quality test results, include deleterious materials.
d. Fine aggregate quality test results.
e. Mill certificates for cement and supplemental cementitious materials.

f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating, and Lithium Nitrate admixtures.
g. Specified flexural strength, slump, and air content.
h. Documentation of required average CQC flexural strength, Ra.
i. Recommended proportions/volumes for proposed mixture and each of three trial water-cementitious materials ratios.
j. Individual beam and cylinder breaks.
k. Flexural and compressive strength summaries and plots.
l. Correlation ratios for acceptance testing and CQC testing.
m. Historical record of test results, documenting production standard deviation (if available).

2.12.2.1 Water-Cement Ratio

At least three different water-cement ratios, which will produce a range of strength encompassing that required on the project, shall be used. The maximum allowable water-cement ratio required in paragraph: Specified Flexural Strength, above will be the equivalent water-cement ratio. Laboratory trial mixtures shall be proportioned for maximum permitted slump and air content.

2.12.2.2 Trial Mixture Studies

Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for each placing method (slip form, fixed form, or hand placement) proposed. The temperature of concrete in each trial batch shall be reported. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

2.12.2.3 Mixture Proportioning for Flexural Strength

The following step by step procedure shall be followed:

a. Fabricate all beams for each mixture from the same batch or blend of batches. Fabricate and cure all beams in accordance with ASTM C192/C192M, using 152 x 152 mm (6 x 6 inch) steel beam forms.

b. Cure test beams from each mixture for 3, 7, 14, and 28 90-day flexural tests; 6 beams to be tested per age.

c. Test beams in accordance with ASTM C78/C78M or KS F 2325.

d. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:
   3-day flexural strength
   7-day flexural strength
   14-day flexural strength
   28-day flexural strength
   90-day flexural strength

e. From these graphs select a w/c that will produce a mixture giving a 28 90-day flexural strength equal to the required strength determined in accordance with the next paragraph.

f. Using the above selected w/c, select from the graphs the expected 3, 7 and 14-day flexural strengths.

g. From the above expected strengths for the selected mixture, determine the Ratio of the 7-day flexural strength of the selected mixture to the 28 90-day flexural strength of the mixture (for CQC control).

h. From the above expected strengths for the selected mixture, determine the Ratio of the 14-day flexural strength of the selected mixture to the 28 90-day flexural strength of the mixture (for acceptance).

i. If there is a change in materials, additional mixture design studies shall be made using the new materials and new Correlation Ratios shall be determined.

j. No concrete pavement shall be placed until the Contracting Officer has approved the Contractor's mixture proportions. The approved water-cementitious materials ratio shall not exceed the maximum value specified in paragraph: Specified Flexural Strength, above and shall not be increased without the Contracting Officer's written approval.

a. Fabricate all beams and cylinders for each mixture from the same batch or blend of batches. Fabricate and cure all beams and cylinders in accordance with ASTM C192/C192M, using 152 x 152 mm (6 x 6 inches) steel beam forms and 152 x 305 mm (6 x 12 inches) single-use cylinder forms.

b. Cure test beams from each mixture for 3, 7, 14, 28 and 90-day flexural tests; 6 beams to be tested per age.

c. Cure test cylinders from each mixture for 3, 7, 14, 28 and 90-day compressive strength tests; 6 cylinders to be tested per age.

d. Test beams in accordance with ASTM C78/C78M or KS F 2325, cylinders in accordance with ASTM C39/C39M or KS F 2405.

e. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:

3-day flexural strength
7-day flexural strength
14-day flexural strength
28-day flexural strength
90-day flexural strength

3-day compressive strength
7-day compressive strength
14-day compressive strength
28-day compressive strength
90-day compressive strength

f. From these graphs select a w/c that will produce a mixture giving a 28 90-day flexural strength equal to the required strength determined in accordance with the next paragraph.

g. Using the above selected w/c, select from the graphs the expected 3, 7, 14, 28 90-day flexural strengths and the expected 3, 7, 14, 28 90-day compressive strengths for the mixture.

h. From the above expected strengths for the selected mixture determine the following Correlation Ratios:

(1) Ratio of the 14-day compressive strength of the selected mixture to the 28 90-day flexural strength of the mixture (for acceptance).

(2) Ratio of the 7-day compressive strength of the selected mixture to the 28 90-day flexural strength of the mixture (for CQC control).

i. If there is a change in materials, additional mixture design studies shall be made using the new materials and new Correlation Ratios shall be determined.

j. No concrete pavement shall be placed until the Contracting Officer has approved the Contractor's mixture proportions. The approved water-cementitious materials ratio shall not exceed the maximum value specified in the next paragraph and shall not be increased without the Contracting Officer's written approval.

2.12.3 Average CQC Flexural Strength Required for Mixtures

In order to ensure meeting the strength requirements specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES above, during production, the mixture proportions selected during mixture proportioning studies and used during construction shall produce a required average CQC flexural strength exceeding the specified strength, R, by the amount indicated below. This required average CQC flexural strength, Ra, will be used only for CQC operations as specified in paragraph: TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3 and as specified in the previous paragraph. During production, the required Ra shall be adjusted , as appropriate and as approved, based on the standard deviation of equivalent 28 90 average 28 90-day strengths being attained during paving.

a. From Previous Test Records: Where a concrete production facility has previous test records current to within 18 months, a standard deviation shall be established in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified flexural strength or strengths within 1 MPa (150 psi) of the 28 90-day flexural strength specified for the proposed work, and shall consist of at least 30 consecutive tests. Perform verification testing, as directed by the Contracting Officer, to document the current strength. A strength test shall be the average of the strengths of two specimens made from the same sample of concrete and tested at 28 90 days. Required average CQC flexural strength, Ra, used as the basis for selection of concrete proportions shall be the value from the equation that follows, using the standard deviation as determined above:

$$Ra = R + 1.34S$$

Where: S = standard deviation
R = specified flexural strength
Ra = required average flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

b. Without Previous Test Records: When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength, Ra, shall be determined by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following. If used, forms shall be in place, cleaned, coated, and adequately supported. Any reinforcing steel needed shall be at the paving site. All transporting and transfer equipment shall be ready for use, clean, and free of hardened concrete and foreign material. Equipment for spreading, consolidating, screeding, finishing, and texturing concrete shall be at the paving site, clean and in proper working order. All equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Precaution

When windy conditions during paving appear probable, equipment and material shall be at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.2 Proposed Techniques

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment and profilographs; demolition of existing pavements, as specified; pavement diamond grinding equipment and procedures. Submit for approval the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes and hand placement areas. No deviation from the jointing pattern shown on the drawings shall be made without written approval of the Contracting Officer.

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Data on the curing equipment, media and methods to be used.

e. Data on profilograph and methods to measure pavement smoothness.

f. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Underlying material, upon which concrete is to be placed shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, the underlying material shall be well drained and shall have been satisfactorily graded by string-line controlled, automated, trimmer/fine grader and uniformly compacted in accordance with the applicable Section of these specifications. The surface of the underlying material shall be tested as to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade, or filled with concrete monolithically with the pavement. Low areas filled with concrete shall not be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Any underlying material disturbed by construction operations shall be reworked and recompacted to specified density immediately in front of the paver. If a slipform paver is used, the same underlying material under the paving lane shall be continued beyond the edge of the lane a sufficient distance and shall be thoroughly compacted and true to grade to provide a suitable trackline for the slipform paver and firm support for the edge of the paving lane.

3.2.2 Traffic on Underlying Material

After the underlying material has been prepared for concrete placement, no equipment shall be permitted thereon. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. The surface shall be reworked and reprepared to the satisfaction of the Contracting Officer before concrete is placed. No transporting equipment shall be allowed to operate on the prepared and compacted underlying material in front of the paver-finisher.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. All unhardened concrete shall be immediately covered and protected from the rain or other damaging weather. Any slab damaged by rain or other weather shall be completely removed full depth, by full slab width, to the nearest original joint, and replaced at the Contractor's expense as specified in paragraph: REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS below.

3.3.2 Paving in Hot Weather

When the ambient temperature during paving is expected to exceed 32 degrees C (90 degrees F), the concrete shall be properly placed and finished in accordance with procedures previously submitted, approved, and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C1064/C1064M. Cooling of the mixing water or aggregates or placing in the cooler part of the day may be required to obtain an adequate placing temperature. Steel forms and reinforcing shall be cooled as needed to maintain steel temperatures below 49 degrees C (120 degrees F). Transporting and placing equipment shall be cooled or protected if necessary to maintain proper concrete placing temperature. The finished surfaces of the newly laid pavement shall be kept damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

Maximum Allowable Concrete Placing Temperature	
Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees C (F)
Greater than 60	35 (95)
40-60	30 (85)
Less than 40	27 (80)

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 4.2 of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. Apply monomolecular films after finishing is complete, do not use in the finishing process. When such water treatment is stopped, curing procedures shall be immediately commenced. Plastic shrinkage cracks that occur shall be repaired in accordance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving shall conform to ACI 306R. Special protection measures, as specified herein, shall be used if freezing temperatures are anticipated before the expiration of the specified curing period. Placement of concrete shall not begin unless the ambient temperature is at least 2 degrees C (35 degrees F) and rising. Thereafter, placement of concrete shall be halted whenever the ambient temperature drops below 5 degrees C (40 degrees F). When the ambient temperature is less than 10 degrees C (50 degrees F), the temperature of the concrete when placed shall be not less than 10 degrees C (50 degrees F) nor more than 25 degrees C (75 degrees F). Heating of the mixing water or aggregates will be required to regulate the concrete placing temperature. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing. If allowed under paragraph: MIXTURE PROPORTIONS in PART 2, an accelerating admixture may be used when the ambient temperature is below 10 degrees C (50 degrees F). Covering and other means shall be provided for maintaining the concrete at a temperature of at least 10 degrees C (50 degrees F) for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Remove pavement slabs damaged by freezing or falling below freezing temperature to full depth, by full slab width, to the nearest original joint, and replace at the Contractor's expense as specified in paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS.

3.4 CONCRETE PRODUCTION

Batching, mixing, and transporting equipment shall have a capacity sufficient to maintain a continuous, uniform forward movement of the paver of not less than 0.8 m (2.5 feet) per minute. Concrete transported in non-agitating equipment shall be deposited in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 32 degrees C (90 degrees F), the time shall be reduced to 30 minutes. Concrete transported in truck mixers shall be deposited in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 32 degrees C (90 degrees F), the time shall be reduced to 60 minutes. Every load of concrete delivered to the paving site shall be accompanied by a batch ticket from the operator of the batching plant. Tickets shall be on approved forms and shall show at least the mass, or volume, of all ingredients in each batch delivered, the water meter and revolution meter reading on truck mixers and the time of day. Tickets shall be delivered to the placing foreman who shall keep them on file and deliver them to the Government weekly, or as directed by the Contracting Officer.

3.4.1 Batching and Mixing Concrete

Scale pivots and bearings shall be kept clean and free of rust. Any equipment which fails to perform as specified shall immediately be removed from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Non-agitating equipment shall be used only on smooth roads and for haul time less than 15 minutes. Concrete shall be deposited as close as possible to its final position in the paving lane. All equipment shall be operated to discharge and transfer concrete without segregation. In no case shall dumping of concrete in discrete piles be permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete will be permitted.

3.5 PAVING

3.5.1 General Requirements

Pavement shall be constructed with paving and finishing equipment utilizing rigid fixed forms or by use of slipform paving equipment. Paving and finishing equipment and procedures shall be capable of constructing paving lanes of the required width at a rate of at least 0.8 m (2.5 feet) of paving lane per minute on a routine basis. Paving equipment and its operation shall be controlled, and coordinated with all other operations, such that the paver-finisher has a continuous forward movement, at a reasonably uniform speed, from beginning to end of each paving lane, except for inadvertent equipment breakdown. Backing the paver and refinishing a lane is not permitted. Remove and replace concrete refinished in this manner. Failure to achieve a continuous forward motion requires halting operations, regrouping, and modifying operations to achieve this requirement. Workmen with foreign material on their footwear or construction equipment that might deposit foreign material shall not be permitted to walk or operate in the plastic concrete. Where an open-graded granular base is required under the concrete, select paving equipment and procedures which will operate properly on the base course without causing displacement or other damage.

3.5.2 Consolidation

Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than 50 mm (2 inches). Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 150 to 400 mm (6 to 15 inches) on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of the paving operation and approved adjustment of the equipment or procedures.

3.5.3 Operation

When the paver approaches a header at the end of a paving lane, a sufficient amount of concrete shall be maintained ahead of the paver to provide a roll of concrete which will spill over the header. The amount of extra concrete shall be sufficient to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. The spud vibrators in front of the paver shall be brought as close to the header as possible before they are lifted. Additional consolidation shall be provided adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement. Screeds or extrusion plates shall be electronically controlled from the previously placed pavement so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. The overlapping area of existing pavement surface shall at all times be kept completely free of any loose or bonded foreign material as the paver-finisher operates across it. When the paver travels on existing pavement, approved provisions shall be made to prevent damage to the existing pavement. Pavers using transversely oscillating screeds shall not be used to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

The paver-finisher, and its gang-mounted vibrators, together with its operating procedures shall be adjusted and operated and coordinated with the concrete mixture being used to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. The paver-finisher shall make only one pass across the pavement; multiple passes will not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. If any equipment or operation fails to produce the above results, the paving shall be stopped, the equipment shall be replaced or properly adjusted, the operation shall be appropriately modified, or the mixture proportions modified, in order to produce the required results before recommencing paving. No water, other than fog sprays (mist) as specified in paragraph: Prevention of Plastic Shrinkage Cracking above, shall be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

Paving equipment for fixed-form paving and the operation thereof shall conform to the requirements of paragraph EQUIPMENT, and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

a. Straight forms shall be made of steel and shall be furnished in sections not less than 3 m (10 feet) in length. Flexible or curved forms of proper radius shall be used for curves of 31 m (100 feet) radius or less. Wood forms for curves and fillets shall be made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend. Wood forms shall be adequate in strength and rigidly braced. Forms shall have a depth equal to the pavement thickness at the edge. Where the project requires several different slab thicknesses, forms may be built up by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. The base width of the one-piece or built-up form shall be not less than eight-tenths of the vertical height of the form, except than forms 200 mm (8 inches) or less in vertical height shall have a base width not less than the vertical height of the form. Maximum vertical deviation of top of any side form, including joints, shall not vary from a true plane more than 3 mm (1/8 inch) in 3 m (10 feet), and the upstanding leg shall not vary more than 6 mm (1/4 inch). Where keyway forms are required, they shall be rigidly attached to the main form so no displacement can take place. Metal keyway forms shall be tack-welded to steel forms. Keyway forms shall be so aligned that there is no variation over 6 mm (1/4 inch) either vertically or horizontally, when tested with a 4 m (12 feet) template after forms are set, including tests across form joints.

b. Form sections shall be tightly locked and shall be free from play or movement in any direction. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms will not deviate vertically more than 3 mm (0.01 feet) from required grade and elevations indicated. Conformity to the alignment and grade elevations shown on the drawings shall be checked and necessary corrections shall be made immediately prior to placing the concrete. The forms shall be cleaned and oiled each time before concrete is placed. No concrete shall be placed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

e. Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled by methods which will not crack or spall the existing pavement. After use, the holes shall be filled flush with the surrounding surface using approved material, prior to overlying materials being placed. Any method which does not hold the form securely or which damages the existing pavement shall be immediately discontinued. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location without proceeding further until the proposed method is approved by the Contracting Officer.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time, as directed. Remove forms by procedures that do not injure the concrete. Bars or heavy metal tools shall not be used directly against the concrete in removing the forms. Any concrete found to be defective after form removal shall be repaired promptly, using procedures specified or as directed.

3.5.6 Slipform Paving

3.5.6.1 General

Paving equipment for slipform paving and the operation thereof shall conform to the requirement of paragraph EQUIPMENT, and all requirements specified herein. The slipform paver shall shape the concrete to the specified and indicated cross section, meeting all tolerances, in one pass. The slipform paver shall finish the surface and edges so that only a very minimum isolated amount of hand finishing is required. If the paving operation does not meet the above requirements and the specified tolerances, immediately stop the operation, and regroup and replace or modify any equipment as necessary, modify paving procedures or modify the concrete mix, in order to resolve the problem. The slipform paver shall be automatically electronically controlled from a taut wire guideline for horizontal alignment and on both sides from a taut wire guideline for vertical alignment, except that electronic control from a ski operating on a previously constructed adjoining lane shall be used where applicable for either or both sides. Automatic, electronic controls for vertical alignment shall always be used on both sides of the lane. Control from a slope-adjustment control or control operating from the underlying material shall never be used. Side forms on slipform pavers shall be properly adjusted so that the finished edge of the paving lane meets all specified tolerances. Dowels in longitudinal construction joints shall be installed as specified below. The installation of these dowels by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete shall not be permitted. (Army Only; If a keyway is required, a 0.45 to 0.55 mm (26 gauge) thick metal keyway liner shall be installed as the keyway is extruded. Keyway forms shall not vary more than plus or minus 3 mm (1/8 inch) from the dimensions indicated and shall not deviate more than plus or minus 6 mm (1/4 inch) from the mid-depth of the pavement. There shall be no abrupt offset either horizontally or vertically in the completed keyway. The keyway liner shall be protected and shall remain in place and become part of the joint.)

3.5.6.2 Guideline for Slipform Paving

Accurately and securely install guidelines well in advance of concrete placement. Provide supports at necessary intervals to eliminate all sag in the guideline when properly tightened. The guideline shall be high strength wire set with sufficient tension to remove all sag between supports. Supports shall be securely staked to the underlying material or other provisions made to ensure that the supports will not be displaced when the guideline is tightened or when the guideline or supports are accidentally touched by workmen or equipment during construction. The appliances for attaching the guideline to the supports shall be capable of easy adjustment in both the horizontal and vertical directions. When it is necessary to leave gaps in the guideline to permit equipment to use or cross underlying material, provisions shall be made for quickly and accurately replacing the guideline without any delay to the forward progress of the paver. Supports on either side of the gap shall be secured in such a manner as to avoid disturbing the remainder of the guideline when the portion across the gap is positioned and tightened. The guideline across the gap and adjacent to the gap for a distance of 60 m (200 feet) shall be checked for horizontal and vertical alignment after the guideline across the gap is tightened. Vertical and horizontal positioning of the guideline shall be such that the finished pavement shall conform to the alignment and grade elevations shown on the drawings within the specified tolerances for grade and smoothness. The specified tolerances are intended to cover only the normal deviations in the finished pavement that may occur under good supervision and do not apply to setting of the guideline. The guideline shall be set true to line and grade.

3.5.6.3 Laser Controls

If the Contractor proposes to use any type of automatic laser controls, submit a detailed description of the system and perform a trial field demonstration in the presence of the Contracting Officer at least one week prior to start of paving. Approval of the control system will be based on the results of the demonstration and on continuing satisfactory operation during paving.

3.5.7 Placing Reinforcing Steel

The type and amount of steel reinforcement shall be as shown on the drawings.

3.5.7.1 Pavement Thickness Greater Than 300 mm (12 inches)

For pavement thickness of 300 mm (12 inches) or more, the reinforcement steel shall be installed by the strike-off method wherein a layer of concrete is deposited on the underlying material, consolidated, and struck to the indicated elevation of the steel reinforcement. The reinforcement shall be laid upon the prestruck surface, and the remaining concrete shall then be placed and finished in the required manner. When placement of the second lift causes the steel to be displaced horizontally from its original position, provisions shall be made for increasing the thickness of the first lift and depressing the reinforcement into the unhardened concrete to the required elevation. The increase in thickness shall be only as necessary to permit correct horizontal alignment to be maintained. Any portions of the bottom layer of concrete that have been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with newly mixed concrete without additional cost to the Government.

3.5.7.2 Pavement Thickness Less Than 300 mm (12 Inches)

For pavements less than 300 mm (12 inches) thick, the reinforcement shall be positioned on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Concrete shall be vibrated after the steel has been placed. Regardless of placement procedure, the reinforcing steel shall be free from coatings which could impair bond between the steel and concrete, and laps in the reinforcement shall be as indicated. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated. If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, the entire operating procedure and equipment proposed shall be submitted for approval at least 30 days prior to proposed start of paving.

3.5.8 Placing Dowels and Tie Bars

The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 3 mm per 0.3 meter (1/8 inch per 1 feet). Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of plus or minus 15 mm (5/8 inch). The vertical location on the face of the slab shall be within a tolerance of plus or minus 13 mm (1/2 inch). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels and tie bars shall not be placed closer than 0.6 times the dowel bar tie bar length to the planned joint line. If the last regularly spaced longitudinal dowel tie bar is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar tie bar length, but not closer than 150 mm (6 inches) to its nearest neighbor. Dowel (tie bar) interference at a transverse joint-longitudinal joint intersection shall be resolved by deleting the closest transverse dowel (tie bar). Dowels shall be installed as specified in the following subparagraphs.

3.5.8.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires. At the Contractor's option, in lieu of the above, dowels and tie bars in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels and tie bars are installed within specified tolerances.

3.5.8.2 Construction Joints-Fixed Form Paving

Install dowels and tie bars by the bonded-in-place method or the drill-and-dowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels and tie bars in construction joints shall be as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, closer spacing with additional dowels or tie bars shall be used.

3.5.8.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for 7 days or reached a minimum compressive strength of 17 MPa (2,500 psi) flexural strength of 3.1 MPa (450 psi) before drilling commences. Holes 3 mm (1/8 inch) greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Continuing damage shall require modification of the equipment and operation. Depth of dowel hole shall be within a tolerance of plus/minus 13 mm (1/2 inch) of the dimension shown on the drawings. Upon completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above. Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars shall be installed at the paver, in front of the transverse screed or extrusion plate. Tie bars shall not be installed in preformed holes. A standard keyway shall be constructed, and the bent tie bars shall be inserted into the plastic concrete through a 0.45 to 0.55 mm (26 gauge) thick metal keyway liner. The keyway liner shall be protected and shall remain in place and become part of the joint. When bending tie bars, the radius of bend shall not be less than the minimum recommended for the particular grade of steel in the appropriate material standard. Before placement of the adjoining paving lane, the tie bars shall be straightened, using procedures which will not spall the concrete around the bar.

3.5.8.4 Lubricating Dowel Bars

The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed.

3.6 FINISHING

Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Any operations which produce more than 3 mm (1/8 inch) of mortar-rich surface (defined as deficient in plus 4.75 mm (No. 4 sieve) size aggregate) shall be halted immediately and the equipment, mixture, or procedures modified as necessary. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

The machine shall be designed to straddle the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

3.6.2 Machine Finishing with Slipform Pavers

The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled nonrotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, the paving operation shall be immediately stopped and the equipment, mixture, or operation modified to prevent formation of such slurry. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

3.6.3 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of cutting straightedges. Such straightedges shall be 4 m (12 feet) in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 1 m (3 feet) longer than one-half the width of the pavement. The surface shall then be tested for trueness with a straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated with an internal vibrator, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph: ACCEPTABILITY OF WORK in PART 1. This straightedging shall not be used as a replacement for the straightedge testing of paragraph: Surface Smoothness in PART 1. Long-handled, flat bull floats shall be used very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, the paving operation shall be stopped and the equipment, mixture or procedures adjusted to eliminate the surface defects. Finishing with hand floats and trowels shall be held to the absolute minimum necessary. Extreme care shall be taken to prevent overfinishing joints and edges. The surface finish of the pavement shall be produced essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations shall be subject to approval and shall be modified when directed.

3.6.4 Hand Finishing

Use hand finishing operations only as specified below.

3.6.4.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. The template shall be at least 300 mm (1 feet) longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall be at least 3 m (10 feet) long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom. Grate tampers (jitterbugs) shall not be used.

3.6.4.2 Finishing and Floating

As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, the entire surface shall be tamped with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed, consolidated and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

3.6.5 Texturing

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, the surface of the pavement shall be given a texture as described herein. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris.

3.6.5.1 Burlap Drag Surface

Surface texture shall be applied by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. The drag shall be operated with the fabric moist, and the fabric shall be cleaned or changed as required to keep clean. The dragging shall be done so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.5.2 Artificial Turf Drag Surface

Artificial turf texture shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf.

3.6.5.3 Broom Texturing

Brooming should be completed before the concrete has hardened to the point where the surface will be unduly torn or roughened, but after hardening has progressed enough so that the mortar will not flow and reduce the sharpness of the scores. Successive passes of the broom shall be overlapped the minimum necessary to obtain a uniformly textured surface. Brooms shall be washed thoroughly at frequent intervals during use. Worn or damaged brooms shall be removed from the job site. Hand brooming will be permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, the brooms shall have handles longer than half the width of slab to be finished. The hand brooms shall be drawn transversely across the surface from the center line to each edge with slight overlapping strokes.

3.6.5.4 Wire-Comb Texturing

Surface texture shall be applied using an approved mechanical wire comb drag operated to comb the surface transverse to the pavement center line. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. Texturing shall be completed before the concrete has hardened to the point where the surface and edges will be unduly torn, but after hardening has progressed to the point where the serrations will not close up. The serrations shall be 2 to 5 mm (1/16 to 3/16 inch) deep, 1.5 to 3 mm (1/16 to 1/8 inch) wide, and spaced 9.5 mm 3/8 inch) apart. Transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm (1/2 inch) of a true line.

3.6.5.5 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 6 mm (1/4 inch) deep and 6 mm (1/4 inch) wide at a spacing between groove centerlines of 37 mm (1-1/2 inches). These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to attain sufficient strength to prevent aggregate spalling. Grooves shall not be cut within 150 mm (6 inches) of a runway centerline, transverse joint, or crack; and they shall not be cut through neoprene compression seals. Transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm (1/2 inch) of a true line.

3.6.6 Edging

After texturing has been completed, the edge of the slabs along the forms, along the edges of slipformed lanes, and at the joints shall be carefully finished with an edging tool to form a smooth rounded surface of 3 mm (1/8 inch) radius. Tool marks shall be eliminated, and the edges shall be smooth and true to line. No water shall be added to the surface during edging. Extreme care shall be taken to prevent overworking the concrete.

3.6.7 Outlets in Pavement

Recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement shall be constructed to conform to the details and dimensions shown. The concrete in these areas shall be carefully finished to provide a surface of the same texture as the surrounding area that will be within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Concrete shall be continuously protected against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, the damaged pavement shall be removed and replaced, and another method of curing shall be employed as directed. Curing shall be accomplished by one of the following methods .

3.7.2 Membrane Curing

A uniform coating of white-pigmented, membrane-forming, curing compound shall be applied to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing . Along the formed edge faces, it shall be applied immediately after the forms are removed. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water, and the curing compound applied as soon as the free water disappears. The curing compound shall be applied to the finished surfaces by means of an approved automatic spraying machine. The curing compound shall be applied with an overlapping coverage that will give a two-coat application at a coverage of 10 square meters per Liter (400 square feet per gallon), plus or minus 5.0 percent for each coat. A one-coat application may be applied provided a uniform application and coverage of 5 square meters per Liter (200 square feet per gallon), plus or minus 5.0 percent is obtained. The application of curing compound by hand-operated, mechanical powered pressure sprayers will be permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, a second coat shall be applied in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be immediately resprayed. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.3 Moist Curing

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, or until curing compound is applied, commencing immediately after finishing. If forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. Lap sheets to provide full coverage. Provide an approved work system to ensure that moist curing is continuous 24 hours per day and that the entire surface is wet.

3.8 JOINTS

3.8.1 General Requirements for Joints

Joints shall conform to the locations and details indicated and shall be perpendicular to the finished grade of the pavement. All joints shall be straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 13 mm (1/2 inch). Where any joint fails to meet these tolerances, the slabs adjacent to the joint shall be removed and replaced at no additional cost to the Government. No change from the jointing pattern shown on the drawings shall be made without written approval of the Contracting Officer. Joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS .

3.8.2 Longitudinal Construction Joints

Dowels or keys or tie bars shall be installed in the longitudinal construction joints, or the edges shall be thickened as indicated. Dowels Tie bars shall be installed as specified above. If any length of completed keyway of 1.5 m (5 feet) or more fails to meet the previously specified tolerances, dowels shall be installed in that part of the joint by drilling holes in the hardened concrete and grouting the dowels in place with epoxy resin. After the end of the curing period, longitudinal construction joints shall be sawed to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. The transverse construction joint shall be installed at a planned transverse joint. Transverse construction joints shall be constructed by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Pavement shall be constructed with the paver as close to the header as possible, and the paver shall be run out completely past the header. Transverse construction joints installed at a planned transverse joint shall be constructed as shown or, if not shown otherwise, shall be dowelled in accordance with paragraph: Dowels Installed in Hardened Concrete, or paragraph: Fixed Form Paving above.

3.8.4 Expansion Joints

Expansion joints shall be formed where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and shall be installed to form a complete, uniform separation between the structure and the pavement. The filler shall be attached to the original concrete placement with adhesive or other fasteners and shall extend the full slab depth. After placement and curing of the adjacent slab, sawcut the sealant reservoir depth from the filler. Adjacent sections of filler shall be fitted tightly together, and the filler shall extend across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Edges of the concrete at the joint face shall be finished with an edger with a radius of 3 mm (1/8 inch).

3.8.5 Slip Joints

Slip joints shall be installed where indicated using the specified materials. Preformed joint filler material shall be attached to the face of the original concrete placement with adhesive or other fasteners. A 19 mm (3/4 inch) deep reservoir for joint sealant shall be constructed at the top of the joint. Edges of the joint face shall be finished with an edger with a radius of 3 mm (1/8 inch).

3.8.6 Contraction Joints

Construct transverse and longitudinal contraction joints by sawing an initial groove in the concrete with a 3 mm (1/8 inch) blade to the indicated depth. During sawing of joints, and again 24 hours later, the CQC team shall inspect all exposed lane edges for development of cracks below the saw cut, and shall immediately report results to the Contracting Officer. If the Contracting Officer determines that there are more uncracked joints than desired, the Contractor will be directed to saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. The time of initial sawing shall vary depending on existing and anticipated weather conditions and shall be such as to prevent uncontrolled cracking of the pavement. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing shall be delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. The sawing operation shall be carried on as required during both day and night regardless of weather conditions. The joints shall be sawed at the required spacing consecutively in the sequence of the concrete placement. Adequate lighting shall be provided for night work. Illumination using vehicle headlights will not be permitted. A chalk line or other suitable guide shall be used to mark the alignment of the joint. Before sawing a joint, the concrete shall be examined closely for cracks, and the joint shall not be sawed if a crack has occurred near the planned joint location. Sawing shall be discontinued when a crack develops ahead of the saw cut. Immediately after the joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly flushed with water and vacuumed until all waste from sawing is removed from the joint and adjacent concrete surface. The surface shall be resprayed with curing compound as soon as free water disappears. Necessary precautions shall be taken to insure that the concrete is properly protected from damage and cured at sawed joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and shall be maintained until removed immediately before sawing the joint sealant reservoir. The exposed saw cuts on the faces of pilot lanes shall be sealed with bituminous mastic or masking tape. After expiration of the curing period, the upper portion of the groove shall be widened by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. The reservoir shall be centered over the initial sawcut.

3.8.7 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Underlying material in the transition area shall be graded as shown and shall meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

New pavement slabs that are broken, have spalled edges, or contain cracks shall be removed and replaced or repaired, as specified at no cost to the Government. Removal of partial slabs is not permitted. Not more than 15.0 percent of each slab's longitudinal joint edge shall be spalled. Prior to fill-in lane placement, pilot lane slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth to remove the spalled face. All other slabs shall be removed, as directed. The Contracting Officer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be at least 150 mm (6 inches) diameter, and shall be drilled and backfilled with an approved non-shrink concrete. Perform drilling of cores and refilling holes at no expense to the Government.

3.9.2 Slabs with Cracks

Clean cracks that do not exceed 50 mm (2 inches) in depth; then pressure injected full depth with epoxy resin, Type IV, Grade 1. Remove slabs containing cracks deeper than 50 mm (2 inches).

3.9.3 Removal and Replacement of Full Slabs

Where it is necessary to remove full slabs, removal shall be in accordance with paragraph: Removal of Existing Pavement Slab below. Removal and replacement shall be full depth, by full width of the slab, and the limit of removal shall be normal to the paving lane and extend to each original joint. Dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph PLACING DOWELS AND TIE BARS, above. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four edges of the new slab shall thus contain dowels. Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material shall be recompacted and shaped as specified in the appropriate section of these specifications, and the surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

3.9.4 Repairing Spalls Along Joints

Where directed, spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks shall be repaired by first making a vertical saw cut at least 25 mm (1 inch) outside the spalled area and to a depth of at least 50 mm (2 inches). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and into at least 13 mm (1/2 inch) of visually sound concrete. Spalls along joints to be sealed with compression seals shall be sawn, chipped out, and repaired to a depth to restore the full joint-face support. The cavity thus formed shall be thoroughly cleaned with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, a prime coat shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Prime coat for portland cement repairs shall be a neat cement grout and for epoxy resin repairs shall be epoxy resin, Type III, Grade 1. The prepared cavity shall be filled with: Portland cement concrete or latex modified mortar for larger cavities, those more than 0.009 cubic meters (1/3 cubic feet) in size after removal operations; Portland cement mortar for cavities between 0.00085 cubic meters (0.03 cubic feet) and 0.009 cubic meters (1/3 cubic feet); and epoxy resin mortar or epoxy resin or latex modified mortar for those cavities less than 0.00085 cubic meters (0.03 cubic feet) in size. Portland cement concretes and mortars shall be very low slump mixtures, 13 mm (1/2 inch) slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Contracting Officer. Proprietary patching materials may be used, subject to approval by the Contracting Officer. The epoxy resin materials shall be placed in the cavity in layers not over 50 mm (2 inches) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 60 degrees C (140 degrees F) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints. The reservoir shall be thoroughly cleaned and then sealed with the sealer specified for the joints. In lieu of sawing, spalls not adjacent to joints and popouts, both less than 150 mm (6 inches) in maximum dimension, may be prepared by drilling a core 50 mm (2 inches) in diameter greater than the size of the defect, centered over the defect, and 50 mm (2 inches) deep or13 mm (1/2 inch) into sound concrete, whichever is greater. The core hole shall be repaired as specified above for other spalls.

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Diamond grind slabs containing weak surfaces less than 6 mm (1/4 inch) thick to remove the weak surface. Diamond grinding shall be in accordance with paragraph DIAMOND GRINDING OF PCC SURFACES in PART 1. All ground areas shall meet the thickness, smoothness and grade criteria of paragraph ACCEPTANCE REQUIREMENTS in PART 1. Remove and replace slabs containing weak surfaces greater than 6 mm (1/4 inch) thick.

3.9.6 Repair of Pilot Lane Vertical Faces

Excessive edge slump and joint face deformation shall be repaired in accordance with paragraph EDGE SLUMP AND JOINT FACE DEFORMATION in PART 1. Inadequate consolidation (honeycombing or air voids) shall be repaired by saw cutting the face full depth along the entire lane length with a diamond blade. Obtain cores, as directed, to determine the depth of removal.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Existing concrete pavement shall be removed at locations indicated on the drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, the remaining edge shall again be surveyed to quantify any damage caused by Contractor's removal operations. Perform both surveys in the presence of the Contracting Officer. Repairs shall be made as indicated and as specified herein. All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface, forming rectangular areas.

3.10.1 Removal of Existing Pavement Slab

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, the joint between the removal area and adjoining pavement to stay in place shall first be cut full depth with a standard diamond-type concrete saw. Next, a full depth saw cut shall be made parallel to the joint at least 600 mm (24 inches) from the joint and at least 150 mm (6 inches) from the end of any dowels. This saw cut shall be made with a wheel sawdiamond saw as specified in paragraph: Sawing Equipment. All pavement to be removed beyond this last saw cut shall be removed in accordance with the approved demolition work plan. All pavement between this last saw cut and the joint line shall be removed by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of concrete may be carefully broken up and removed using hand-held jackhammers, 14 kg (30 lb) or less, or other approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Slabs which are damaged during construction shall be removed and replaced as directed by the Contracting Officer at no cost to the Government. Repair of previously existing damage areas will be considered a subsidiary part of concrete pavement construction. All exposed keys and keyways shall be sawn off full depth.

3.10.2.1 Spall Repair

Not more than 15.0 percent of each slab's edge shall be spalled as a result of the Contractor's actions. Unless otherwise directed by the Contracting Officer, damaged slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth on the exposed face to remove the spalled face. Repair materials and procedures shall be as previously specified in paragraph: Repairing Spalls Along Joints.

3.10.2.2 Underbreak and Underlying Material

All underbreak shall be repaired by removal and replacement of the damaged slabs in accordance with paragraph: Removal and Replacement of Full Slabs above. The underlying material adjacent to the edge of and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient underlying material shall be kept in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Any material under the portion of the concrete pavement to remain in place which is disturbed or loses its compaction shall be carefully removed and replaced with concrete.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance of the work by the Government. Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured flexural strength of 3.6 MPa (550 psi). and approved means are furnished to prevent damage to the slab edge. All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence. Special care shall be used where Contractor's traffic uses or crosses active airfield pavement. Power broom other existing pavements at least daily when traffic operates. For fill-in lanes, equipment shall be used that will not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

3.12.1 Testing and Inspection by Contractor

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials (cement, GGBF and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Samples of concrete shall be obtained at the point of delivery to the paver. Testing by the Government will in no way relieve the Contractor of the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. This testing shall be performed regardless of any other testing performed by the Government, either for pay adjustment purposes or for any other reason.

3.12.2 Testing and Inspection Requirements

Contractor CQC sampling, testing, inspection and reporting shall be in accordance with the following Table.

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Fine Aggregate Gradation and Fineness Modulus			
2 per lot	ASTM C136 or KS F 2502 sample at belt	9 of 10 tests vary <0.15 from average	
		Outside limits on any sieve	Retest
		2nd failure	Stop, repair, retest
Coarse Aggregate Gradation			
2 per lot	ASTM C136 or KS F 2502 sample at belt	Outside limits on any sieve	Retest
		2nd failure	report to COR, correct
		2 consecutive avgs of 5 tests out	report to COR, stop ops, repair, retest
Workability Factor and Coarseness Factor Computation			
Same as C.A. and F.A.	see paragraph AGGREGATES	Use individual C.A. and F.A. gradations. Combine using batch ticket percentages. Tolerances: +/- 3 points on WF; +/- 5 points on CF from approved mix design values	Check batching tolerances, recalibrate scales
Aggregate Deleterious, Quality, and ASR Tests			
Every 30 days	see paragraph AGGREGATES		Stop production, retest, replace aggregate. Increase testing interval to 90 days if previous 2 tests pass
Plant - Scales, Weighing Accuracy			
Monthly	NRMCA QC 3		Stop plant ops, repair, recalibrate
Plant - Batching and Recording Accuracy			
Weekly	Record/Report	Record required/recorded/actual batch mass	Stop plant ops, repair, recalibrate
Plant - Batch Plant Control			
Every lot	Record/Report		Record type/amt of each material per lot

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Plant - Mixer Uniformity - Stationary Mixers			
Every 4 months during paving	COE CRD-C 55	After initial approval, use abbreviated method	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
Plant - Mixer Uniformity - Truck Mixers			
Every 4 months during paving	ASTM C94/C94M or KS F 4009	Random selection of truck.	Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
Concrete Mixture - Air Content			
When test specimens prepared + 2 random	ASTM C231/C231M or KS F 2421 sample at paving site	Individual test control chart: Warning +/-1.0	Adjust AEA, retest
		Individual test control chart: Action +/-1.5	Halt operations, repair, retest
		Range between 2 consecutive tests: Warning +2.0	Recalibrate AEA dispenser
		Range between 2 consecutive tests: Action +3.0	Halt operations, repair, retest
Concrete Mixture - Unit Weight and Yield			
Same as Air Content	ASTM C138/C138M sample at paving site	Individual test basis: Warning Yield -0/+1 percent	Check batching tolerances
		Individual test basis: Action Yield -0/+5 percent	Halt operations
Concrete Mixture - Slump			
When test specimens prepared + 4 random	ASTM C143/C143M or KS F 2402 sample at paving site	Individual test control chart: Upper Warning - 13 mm(1/2 inch) below max	Adjust batch masses within max W/C ratio
		Individual test control chart: Upper Action - maximum allowable slump	Stop operations, adjust, retest
		Range between each consecutive test: 38 mm(1-1/2 inches)	Stop operations, repair, retest

TABLE 6 CONTRACTOR TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
Concrete Mixture - Temperature			
When test specimens prepared	ASTM C1064/C1064M sample at paving site	See paragraph WEATHER LIMITATIONS	
Concrete Mixture - Strength			
8 per lot	ASTM C31/C31M sample at paving station	See paragraph CONCRETE STRENGTH TESTING for CQC	
Paving - Inspection Before Paving			
Prior to each paving operation	Report	Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items	
Paving - Inspection During Paving			
During paving operation		Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.	
Paving - Vibrators			
Weekly during paving	COE CRD-C 521	Test frequency (in concrete), and amplitude (in air), measure at tip/head and average.	Repair or replace defective vibrators.
Moist Curing			
2 per lot, min 4 per day	Visual		Repair defects, extend curing by 1 day
Membrane Compound Curing			
Daily	Visual	Calculate coverage based on quantity/area	Respray areas where coverage defective. Recalibrate equipment
Cold Weather Protection			

TABLE 6 CONTRACTOR TESTING AND INSPECTION REQUIREMENTS			
Frequency	Test Method	Control Limit	Corrective Action
Once per day	Visual		Repair defects, report conditions to COR

3.12.3 Concrete Strength Testing for Contractor CQC

Contractor Quality Control operations for concrete strength shall consist of the following steps:

a. Take samples for strength tests at the paving site. Fabricate and cure test cylinders in accordance with ASTM C31/C31M; test them in accordance with ASTM C39/C39M or KS F 2405.

b. Fabricate and cure 2 test cylinders per sublot from the same batch or truckload and at the same time acceptance cylinders are fabricated and test them for compressive strength at 7-day age.

c. Average all 8 compressive tests per lot. Convert this average 7-day compressive strength per lot to equivalent 28 90-day flexural strength using the Correlation Ratio determined during mixture proportioning studies.

d. Compare the equivalent 28 90-day flexural strength from the conversion to the Average Flexural Strength Required for Mixtures from paragraph of same title.

e. If the equivalent average 2890-day strength for the lot is below the Average Flexural Strength Required for Mixtures by 138 kPa (20 psi)flexural strength or more, at any time, adjust the mixture to increase the strength, as approved.

f. Fabricate and cure two beams for every 1,500 cubic meters (2,000 cubic yards) of concrete placed. Fabricate and cure in accordance with ASTM C31/C31M; test at 14-days of age in accordance with ASTM C78/C78M or KS F 2325. Use the flexural strength results to verify the cylinder-beam acceptance correlation ratio.

g. The Contractor's CQC testing agency shall maintain up-to-date control charts for strength, showing the 7-day CQC compressive strength, the 14-day compressive strength (from acceptance tests) and the 28 90-day equivalent flexural strength of each of these for each lot.

a. Take samples for strength tests at the paving site. Fabricate and cure test beams in accordance with ASTM C31/C31M; test them in accordance with ASTM C78/C78M or KS F 2325.

b. Fabricate and cure 2 test beams per sublot from the same batch or truckload and at the same time acceptance beams are fabricated and test them for flexural strength at 7-day age.

c. Average all 8 flexural tests per lot. Convert this average 7-day flexural strength per lot to equivalent 28 90-day flexural strength using the Correlation Ratio determined during mixture proportioning studies.

d. Compare the equivalent 28 90-day flexural strength from the conversion to the Average Flexural Strength Required for Mixtures from paragraph of same title.

e. If the equivalent average 28 90-day strength for the lot is below the Average Flexural Strength Required for Mixtures by 490 kPa (69 psi) flexural strength or more, at any time, adjust the mixture to increase the strength, as approved.

f. The Contractor's CQC testing agency shall maintain up-to-date control charts for strength, showing the 7-day CQC flexural strength and the 28 90-day flexural strength (from acceptance tests) of each of these for each lot.

3.12.4 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all Contractor quality control records.

-- End of Section --

SECTION 32 13 13.06

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES
11/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 301	(2010; Errata 2011) Specifications for Structural Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C215	(2010) Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2006; E2011) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A966/A966M	(2008) Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current
ASTM C1077	(2014) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C78/C78M	(2012; E 2013) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2013) Standard Specification for Slag Cement for Use in Concrete and Mortars

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2011) Steel Bars for Concrete Reinforcement

KS D 7017	(2007) Welded Steel Wire Fabrics
KS D ISO 6935-1	(2009) Steel for the reinforcement of concrete - Part 1: Plain bars
KS F 2402	(2007) Slump of Concrete
KS F 2408	(2000) Method of test for flexural strength of concrete
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2526	(2007) Aggregate for Concrete
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 2563	(2009) Ground granulated blast-furnace slag for use in concrete
KS F 2825	(2007) Rapid Identification of the Alkali Reactivity of Aggregates - Methods of Test for Production Control of Concrete
KS F 4007	(2002) Sheet Materials for Curing Concrete
KS F 4009	(2011) Ready-Mixed Concrete
KS L 5201	(2013) Portland Cement

1.2 RELATED SECTIONS

Portland cement concrete pavement shall use Section 32 11 16.16 BASE COURSE FOR RIGID AND SUBBASE COURSE FOR PERVIOUS PAVING, in addition to this section.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data; G

Curing materials

Admixtures

Dowel

Reinforcement

Submit a complete list of materials including type, brand and applicable reference specifications.

SD-05 Design Data; G

Concrete mix design

Thirty days minimum prior to concrete placement, submit a mix design, with applicable tests, for each strength and type of concrete for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required. Submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted. Obtain acknowledgement of approvals prior to concrete placement. Submit a new mix design for each material source change.

SD-06 Test Reports; G

Aggregate tests

Concrete slump tests

Air content tests

Flexural strength tests

Cementitious materials

SD-07 Certificates; G

Ready-mixed concrete plant

Batch tickets

Cementitious materials

SD-11 Closeout Submittals; G

1.4 DELIVERY, STORAGE, AND HANDLING

ASTM C94/C94M or KS F 4009.

1.5 QUALITY ASSURANCE

1.5.1 Ready-mixed Concrete Plant Certification

Unless otherwise approved by the Contracting Officer, ready mixed concrete shall be produced and provided by a National Ready-Mix Concrete Association (NRMCA) certified plant. If a volumetric mobile mixer is used to produce the concrete, rather than ready-mixed concrete, the mixer(s) must conform to the standards of the Volumetric Mixer Manufacturers Bureau (VMMB). Verification shall be made by a current VMMB conformance plate affixed to the volumetric mixer equipment.

1.5.2 Contractor Qualifications

Unless waived by the Contracting Officer, the Contractor shall meet one of the following criteria:

a. Contractor shall have at least one National Ready Mixed Concrete Association (NMRCA) certified concrete craftsman on site, overseeing each placement crew during all concrete placement.

b. Contractor shall have no less than three NRMCA certified concrete installers, who shall be on site working as members of each placement crew during all concrete placement.

1.5.3 Required Information

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports shall include mill test and all other test for cementitious materials, aggregates, and admixtures. Provide maximum nominal aggregate size, combined aggregate gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Test reports shall be submitted along with the concrete mix design. Sampling and testing of materials, concrete mix design, sampling and testing in the field shall be performed by a commercial testing laboratory which conforms to ASTM C1077. The laboratory shall be approved in writing by the Government.

1.5.4 Batch Tickets

ASTM C94/C94M or KS F 4009. Submit mandatory batch ticket information for each load of ready-mixed concrete.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials in concrete mix shall be 20 to 50 percent non-portland cement pozzolanic materials by weight. Provide test data demonstrating compatibility and performance of concrete satisfactory to Contracting Officer.

2.1.1.1 Cement

ASTM C150/C150M, Type I or II or KS L 5201, Class I or II .

2.1.1.2 Fly Ash and Pozzolan

ASTM C618, Type C, F, or N. Fly ash certificates shall include test results in accordance with ASTM C618.

2.1.1.2 Slag

ASTM C989/C989M or KS F 2563, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120. Certificates shall include test results in accordance with ASTM C989/C989M or KS F 2563.

2.1.2 Water

Water shall conform to ASTM C1602/C1602M. Hot water shall not be used unless approved by the Contracting Officer.

2.1.2 Aggregate

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, or a combination thereof. Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles. Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings. Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles. Both coarse and fine aggregates shall meet the requirements of ASTM C33/C33M.

2.1.2.1 Alkali Reactivity Test

Aggregates to be used in all concrete in projects over 4645 SM (50,000 SF) in size shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C1260 or KS F 2825. The types of aggregates shall be evaluated in a combination which matches the contractors' proposed mix design (including Class F fly ash or GGBF slag), utilizing ASTM C1567. Test results of the combination shall have a measured expansion of less than 0.08 percent at 28 days. Should the test data indicate an expansion of greater than 0.08%, the aggregate(s) shall be rejected and the contractor shall submit new aggregate sources for retesting or may submit additional test results incorporating Lithium Nitrate for consideration.

ASTM C1260 or KS F 2825 shall be modified as follows to include one of the following options:

a. Utilize the contractor's proposed low alkali Portland cement and Class F fly ash in combination for the test proportioning. The laboratory shall use the contractor's proposed percentage of cement and fly ash.

b. Utilize the contractor's proposed low alkali Portland cement and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory shall use the contractor's proposed percentage of cement and GGBF.

c. Utilize the contractor's proposed low alkali Portland cement and Class F fly ash and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory shall use the contractor's proposed percentage of cement, fly ash and GGBF.

2.1.2.2 Fine Aggregates

ASTM C33/C33M or KS F 2526.

2.1.2.3 Coarse Aggregates

ASTM C33/C33M or KS F 2526.

2.1.3 Admixtures

ASTM C494/C494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture or KS F 2560. Do not use calcium chloride admixtures. Where not shown or specified, the use of admixtures is subject to written approval of the Contracting Officer.

ASTM C260/C260M: Air-entraining.

2.1.4 Reinforcement

2.1.4.1 Dowel Bars

Bars shall conform to ASTM A615/A615M, Grade 300, Grade 420 (Grade 40 Grade 60) for plain billet-steel bars of the size and length indicated or KS D ISO 6935-1, B420D-P. Remove all burrs and projections from the bars.

2.1.4.2 Coated Dowel Bars

Bars shall conform to ASTM A615/A615M, Grade 300, Grade 420, (Grade 40, or Grade 60) for plain billet-steel bars of the size and length indicated or KS D ISO 6935-1, B420D-P. Remove all burrs or projections from the dowel bars. Coating system shall conform to AWWA C215, Type 2. Coat the bars with a double coat system or an epoxy coating system for resistance to penetration of oil and salt solutions. The systems shall be in accordance with manufacturer's recommendation for coatings which are not bondable to concrete. Bond the coating to the dowel bar to resist laps or folds during movement of the joint. Coating thickness shall be 0.175 mm (7 mils) minimum and 0.5 mm (20 mils) maximum.

2.1.4.3 Tie Bars

Bars shall be billet or axle steel deformed bars and conform to ASTM A615/A615M or KS D 3504 or ASTM A966/A966M Grade 300, Grade 420 (Grade 40, Grade 60). Epoxy coated in accordance with ASTM A775/A775M.

2.1.4.4 Reinforcement

Deformed steel bar mats shall conform to ASTM A184/A184M or KS D 7017. Bar reinforcement shall conform to ASTM A615/A615M and ASTM A966/A966M, Grade 300 or Grade 420 (Grade 40 or Grade 60) or KS D 3504, SD300 or SD500, as indicated on contract drawings.

2.1.5 Curing Materials

2.1.5.1 White-Burlap-Polyethylene Sheet

ASTM C171 or KS F 4007, 0.10 mm (0.004 inch) thick white opaque polyethylene bonded to 0.31 kg per meter (10 oz/linear yard), 1.0 meter (40 inch) wide burlap.

2.1.5.2 Liquid Membrane-Forming Compound

ASTM C309, white pigmented, Type 2, Class B, free of paraffin or petroleum or KS F 2540.

2.1.6 Joint Fillers and Sealants

Provide as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS32 13 73 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS. New joints shall match existing alignment.

2.2 CONCRETE PAVEMENT

2.2.1 Joint Layout Drawings

If jointing requirements on the project drawings are not compatible with the contractor's placement sequence, the contractor shall submit a joint layout plan shop drawing to the Contracting Officer for approval. No work shall be allowed to start until the joint layout plan is approved. The joint layout plan shall indicate and describe in the detail the proposed jointing plan for contraction joints, expansion joints, and construction joints, in accordance with the following:

a. Indicate locations of contraction joints, construction joints, and expansion joints. Spacing between contraction joints shall not exceed 4.5m (15 feet) unless noted otherwise or approved by the Contracting Officer.

b. The larger dimension of a panel shall not be greater than 125% of the smaller dimension.

c. The minimum angle between two intersecting joints shall be 80 degrees, unless noted otherwise or approved by the Contracting Officer.

d. Joints shall intersect pavement-free edges at a 90 degree angle the pavement edge and shall extend straight for a minimum of 450mm (1.5 feet) from the pavement edge, where possible.

e. Align joints of adjacent panels.

f. Align joints in attached curbs with joints in pavement when possible.

g. Ensure joint depth, widths, and dimensions are specified.

h. Minimum contraction joint depth shall be 1/4 of the pavement thickness. The minimum joint width shall be 3mm (1/8 inch).

i. Use expansion joints only where pavement abuts buildings, foundations, manholes, and other fixed objects.

2.3 CONTRACTOR-FURNISHED MIX DESIGN

Contractor-furnished mix design concrete shall be designed in accordance with ACI 211.1 except as modified herein, and the mix design shall be as specified herein under paragraph entitled "Submittals." The concrete shall have a minimum flexural strength of 4.48MPa (650 pounds per square inch) at 28 days. The concrete may be air entrained. If air entrainment is used the air content shall be 6.0 plus or minus 1.5 percent. Maximum size aggregate for slip forming shall be 38 mm (1.5 inches). The minimum cementitious factor is 335 kg per cubic meter (564 lbs per cubic yard) and slump shall be 25 mm to 75 mm (1 to 3 inches) (or less when slip form is used).

If the cementitious material is not sufficient to produce concrete of the flexural strength required it shall be increased as necessary, without additional compensation under the contract. The cementitious factor shall be calculated using cement, Class F fly ash, and or GGBF slag. The mix shall use a cement replacement (by weight) of 25 percent - 35 percent Class F fly ash, or 40 percent - 50 percent GGBF slag, or a combination of the two. In the combination, each 5 percent of Class F fly ash shall be replaced by 8 percent GGBF slag.

PART 3 EXECUTION

3.1 FORMS

3.1.1 Construction

Construct forms to be removable without damaging the concrete.

3.1.2 Coating

Before placing the concrete, coat the contact surfaces of forms except existing pavement sections where bonding is required, with a non-staining mineral oil, non-staining form coating compound, or two coats of nitro-cellulose lacquer.

3.1.3 Grade and Alignment

Check and correct grade elevations and alignment of the forms immediately before placing the concrete.

3.2 REINFORCEMENT

3.2.1 Dowel Bars

Install bars accurately aligned, vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Before installation thoroughly grease the sliding portion of each dowel. Dowels must remain in position during concrete placement and curing.

3.2.2 Coated Dowel Bars

Install bars, accurately aligned vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Reject coatings which are perforated, cracked or otherwise damaged. While handling avoid scuffing or gouging of the coatings.

3.2.3 Tie Bars

Install bars, accurately aligned horizontally and vertically, at indicated locations. For slipform construction, insert bent tie bars by hand or other approved means.

3.2.4 Setting Slab Reinforcement

Reinforcement shall be positioned on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Reinforcement, when placed in concrete, shall be free of mud, oil, scale or other foreign materials. Place reinforcement accurately and wire securely. The laps at splices shall be

300 mm (12 inches) minimum and the distances from ends and sides of slabs and joints shall be as indicated.

3.3 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.3.1 Measuring

ASTM C94/C94M.

3.3.2 Mixing

ASTM C94/C94M or KS F 4009, except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 29.4 degrees C (85 degrees F), place concrete within 60 minutes. With the approval of the Contracting Officer, a hydration stabilizer admixture meeting the requirements of ASTM C494/C494M Type D, may be used to extend the placement time to 90 minutes. Additional water may be added to bring slump within required limits as specified in Section 11.7 of ASTM C94/C94M or KS F 4009, provided that the specified water-cement ratio is not exceeded.

3.3.3 Conveying

ASTM C94/C94M or KS F 4009.

3.3.4 Placing

Follow guidance of ACI 301, except as modified herein. Do not exceed a free vertical drop of 1.5 m (5 feet) from the point of discharge. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Do not place concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Place concrete continuously at a uniform rate, with minimum amount of segregation, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 3 m (10 feet) of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

3.3.5 Vibration

Immediately after spreading concrete, consolidate concrete with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs 150 mm (6 inches) or more in thickness. Limit duration of vibration to that necessary to produce consolidation of concrete. Excessive vibration will not be permitted. Vibrators shall not be operated in concrete at one location for more than 15 seconds. At the option of the Contractor, vibrating equipment of a type approved by the Contracting Officer may be used to consolidate concrete in unreinforced pavement slabs less than 150 mm (6 inches) thick.

3.3.5.1 Vibrating Equipment

Operate equipment, except hand-manipulated equipment, ahead of the finishing machine. Select the number of vibrating units and power of each unit to properly consolidate the concrete. Mount units on a frame that is capable of vertical movement and, when necessary, radial movement, so vibrators may be operated at any desired depth within the slab or be completely withdrawn from the concrete. Clear distance between frame-mounted vibrating units that have spuds that extend into the slab at intervals across the paving lane shall not exceed 750 mm (30 inches). Distance between end of vibrating tube and side form shall not exceed 50 mm (2 inches). For pavements less than 250 mm (10 inches) thick, operate vibrators at mid-depth parallel with or at a slight angle to the subbase. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 50 mm (2 inches) from subbase, and top of vibrator a3 to 4 mm (1/8 to 1/6inches) below pavement surface. Vibrators may be pneumatic, gas driven, or electric, and shall be operated at frequencies within the concrete of not less than 8,000 vibrations per minute. Amplitude of vibration shall be such that noticeable vibrations occur at 450 mm (1.5 foot) radius when the vibrator is inserted in the concrete to the depth specified.

3.3.6 Cold Weather

Except with authorization, do not place concrete when ambient temperature is below 5 degrees C (40 degrees F) or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 18 and 27 degrees C (65 and 80 degrees F). Methods of heating materials are subject to approval of the Contracting Officer. Do not heat mixing water above 74 degrees C (165 degrees F). Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306.1.

3.3.7 Hot Weather

Maintain required concrete temperature in accordance with Figure 2.1.5 in ACI 305R to prevent evaporation rate from exceeding 0.98 kg of water per square meter (0.2 pound of water per square foot) of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in ACI 305R.

3.4 PAVING

Pavement shall be constructed with paving and finishing equipment utilizing fixed forms or slipforms.

3.4.1 Consolidation

The paver vibrators shall be inserted into the concrete not closer to the underlying material than 50 mm (2 inches). The vibrators or any tamping units in front of the paver shall be automatically controlled so that they shall be stopped immediately as forward motion ceases. Excessive vibration shall not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment shall be vibrated with a hand-operated immersion vibrator. Vibrators shall not be used to transport or spread the concrete.

3.4.2 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates shall overlap the existing pavement the minimum possible, but in no case more than200 mm (8 inches).

3.4.3 Required Results

The paver-finisher shall be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. It shall produce only a very minimum of paste at the surface. Multiple passes of the paver-finisher shall not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), shall be applied to the concrete surface during paving and finishing.

3.4.4 Fixed Form Paving

Forms shall be steel, except that wood forms may be used for curves having a radius of 45 m (150 feet) or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form shall be not less than eight-tenths of the vertical height of the form, except that forms 200 mm (8 inches) or less in vertical height shall have a base width not less than the vertical height of the form. Wood forms for curves and fillets shall be adequate in strength and rigidly braced. Forms shall be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms shall not be set on blocks or on built-up spots of underlying material. Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled without cracking or spalling the existing pavement. Prior to setting forms for paving operations, the Contractor shall demonstrate the proposed form setting procedures at an approved location and shall not proceed further until the proposed method is approved. Forms shall remain in place at least 12 hours after the concrete has been placed. Forms shall be removed without injuring the concrete.

3.4.5 Slipform Paving

The slipform paver shall shape the concrete to the specified and indicated cross section in one pass, and shall finish the surface and edges so that only a very minimum amount of hand finishing is required. Dowels shall not be installed by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete. If a keyway is required, a 0.45 to 0.55 mm (26 gauge) thick metal keyway liner shall be installed as the keyway is extruded. The keyway liner shall be protected and shall remain in place and become part of the joint.

3.4.6 Placing Reinforcing Steel

Reinforcement shall be positioned on suitable chairs securely fastened to the subgrade prior to concrete placement. If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, the entire operating procedure and equipment proposed shall be submitted for approval at least 30 days prior to proposed start of paving.

3.4.7 Placing Dowels and Tie Bars

Dowels shall be installed with alignment not greater than 1 mm per 100 mm (1/8 inch per ft). Except as otherwise specified below, location of dowels shall be within a horizontal tolerance of plus or minus 15 mm (5/8 inch) and a vertical tolerance of plus or minus 5 mm (3/16 inch). The portion of each dowel intended to move within the concrete or expansion cap shall be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. Dowels and tie bars in joints shall be omitted when the center of the dowel or tie bar is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

3.4.7.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal basket assemblies. The dowels and tie bars shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies shall be held securely in the proper location by means of suitable anchors.

3.4.7.2 Construction Joints-Fixed Form Paving

Installation of dowels and tie bars shall be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

3.4.7.3 Dowels Installed in Hardened Concrete

Installation shall be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately 3 mm (1/8 inch) greater in diameter than the dowels shall be drilled into the hardened concrete. Dowels shall be bonded in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel shall not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels shall be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars shall be installed at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, a standard keyway shall be constructed, and the bent tie bars shall be inserted into the plastic concrete through a 0.45 to 0.55 mm (26 gauge) thick metal keyway liner. Tie bars shall not be installed in preformed holes. The keyway liner shall be protected and shall remain in place and become part of the joint. Before placement of the adjoining paving lane, the tie bars shall be straightened, without spalling the concrete around the bar.

3.4.7.4 Expansion Joints

Dowels in expansion joints shall be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times. Transverse and longitudinal surface tolerances shall be 6 mm in 3 m (1/4 inch in 10 feet).

3.5.1 Side Form Finishing

Strike off and screed concrete to the required crown or slope and cross-section by a power-driven transverse finishing machine. Transverse rotating tube or pipe shall not be permitted unless approved by the Contracting Officer. Elevation of concrete shall be such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with two screeds which are readily and accurately adjustable for changes in pavement crown or slope and compensation for wear and other causes. Make as many passes over each area of pavement and at such intervals as necessary to give proper compaction, retention of coarse aggregate near the finished surface, and a surface of uniform texture, true to grade and crown or slope. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length.

3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 6 mm (0.02 foot). Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template.

3.5.1.4 Longitudinal Floating

After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats. Use floats that are not less than 3.65 m (12 feet) long and 150 mm (6 inches) wide and stiffened to prevent flexing and warping.

3.5.2 Texturing

Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement shall be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, Contracting Officer representative, and a representative of the Using Agency shall inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris. Any type of transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm (1/2 inch) of a true line. The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement shall be finished to provide a surface of the same texture as the surrounding area.

3.5.2.1 Burlap Drag Finish

Before concrete becomes non-plastic, finish the surface of the slab by dragging on the surface a strip of clean, wet burlap measuring from 0.91 to 3 m (3 to 10 feet) long and 600 mm (2 feet) wider than the width of the pavement. Select dimension of burlap drag so that at least 0.91 m (3 feet) of the material is in contact with the pavement. Drag the surface so as to produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks.

3.5.2.2 Brooming

Finish the surface of the slab by brooming the surface with a new wire broom at least 450 mm (18 inches) wide. Gently pull the broom over the surface of the pavement from edge to edge just before the concrete becomes non-plastic. Slightly overlap adjacent strokes of the broom. Broom perpendicular to centerline of pavement so that corrugations produced will be uniform in character and width, and not more than 2 mm (1/16 inch) in depth. Broomed surface shall be free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the surface.

3.5.2.3 Wire-Comb Texturing

Surface texture transverse to the pavement center line shall be applied using a mechanical wire comb drag. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. The scores shall be 2 to 5 mm (1/16 to 3/16 inch) deep, 1.5 to 3 mm (1/16 to 1/8 inch) wide, and spaced 10 mm (3/8 inch) apart.

3.5.2.4 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 6 mm (1/4 inch) deep and 6 mm (1/4 inch) wide at a spacing between groove centerlines of 50 mm (2 inches). These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to stiffen sufficiently to prevent dislodging of aggregate. Grooves shall not be cut within 150 mm (6 inches) of a transverse joint or crack.

3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of 3 mm (one-eighth inch). When brooming is specified for the final surface finish, edge transverse joints before starting brooming, then operate broom to obliterate as much as possible the mark left by the edging tool without disturbing the rounded corner left by the edger. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Remaining edges shall be smooth and true to line.

3.5.4 Repair of Surface Defects

Follow guidance of ACI 301.

3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Use White-Burlap-Polyethylene Sheet or liquid membrane-forming compound, except as specified otherwise herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded. Maintain temperature of air next to concrete above 5 degrees C (40 degrees F) for the full curing periods.

3.6.1 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap 300 mm (12 inches). Make sheeting not less than 450 mm (18 inches) wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (re-saturation and re-placing shall take no longer than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

3.6.2 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Total coverage for the two coats shall be at least 4 liters (one gallon) of undiluted compound per 20 square meters (200 square feet). Compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

3.6.2.1 Protection of Treated Surfaces

Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

3.6.3 Liquid Chemical Sealer-Hardener

Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's recommendations. Seal or cover joints and openings in which joint sealant is to be applied as required by the joint sealant manufacturer. The sealer-hardener shall not be applied until the concrete has been moist cured and has aged for a minimum of 30 days. Apply a minimum of two coats of sealer-hardener.

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

The Contractor's approved laboratory shall collect samples of fresh concrete in accordance with ASTM C172/C172M during each working day as required to perform tests specified herein. Make test specimens in accordance with ASTM C31/C31M.3.7.2 Consistency Tests

The Contractor's approved laboratory shall perform concrete slump tests in accordance with ASTM C143/C143M or KS F 2402. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 16 cubic meters (20 cubic yards) (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams and cylinders are made.

3.7.3 Flexural Strength Tests

The Contractor's approved laboratory shall test for flexural strength in accordance with ASTM C78/C78M or KS F 2408. Make four test specimens for each set of tests. Test two specimens at 7 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28-day test results equals or exceeds the specified 28-day flexural strength, and no individual strength test is less than 3.79 MPa (550 pounds per square inch). If the ratio of the 7-day strength test to the specified 28-day strength is less than 65 percent, make necessary adjustments for conformance. Frequency of flexural tests on concrete beams shall be not less than four test beams for each 38 cubic meters (50 cubic yards) of concrete, or fraction thereof, placed. Concrete which is determined to be defective, based on the strength acceptance criteria therein, shall be removed and replaced with acceptable concrete.

3.7.4 Air Content Tests

Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with ASTM C231/C231M or KS F 2421 on samples taken during placement of concrete in forms.

3.7.5 Surface Testing

Surface testing for surface smoothness , edge slump and plan grade shall be performed as indicated below by the Testing Laboratory. The measurements shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Government within 24 hours after measurement is made. A final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, shall be provided to the Government upon conclusion of surface testing.

3.7.5.1 Surface Smoothness Requirements

The finished surfaces of the pavements shall have no abrupt change of 3 mm (1/8 inch) or more, and all pavements shall be within the tolerances specified when checked with a 4 meter (12 foot) straightedge: 5 mm (1/5 inch) longitudinal and 6.5 mm (1/4 inch) transverse directions for roads and streets and 6.5 mm (1/4 inch) for both directions for other concrete surfaces, such as parking areas.

3.7.5.2 Surface Smoothness Testing Method

The surface of the pavement shall be tested with the straightedge to identify all surface irregularities exceeding the tolerances specified above. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines approximately 4.5 m (15 feet) apart. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

3.7.6 Plan Grade Testing and Conformance

The surfaces shall vary not more than 18 mm (0.06 foot) above or below the plan grade line or elevation indicated. Each pavement category shall be checked by the Contractor for conformance with plan grade requirements by running lines of levels at intervals to determine the elevation at each joint intersection.

3.7.7 Test for Pavement Thickness

Measure during concrete placement to determine in-place thickness of concrete pavement.

3.7.8 Reinforcement

Inspect reinforcement prior to installation to assure it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

3.7.9 Dowels

Inspect dowel placement prior to placing concrete to assure that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Dowels shall not deviate from vertical or horizontal alignment after concrete has been placed by more than 3 mm per 300 mm (1/8 inch per foot).

-- End of Section --

SECTION 32 13 73

COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D2628	(1991; R 2011) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	(1989; R 2007) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 548	(1988) Standard Specification for Jet-Fuel and Heat-Resistant Preformed Polychloroprene Elastomeric Joint Seals for Rigid Pavements

1.2 SYSTEM DESCRIPTION

Provide machines, tools, and equipment, used in the performance of the work required by this section, approved before the work is started and maintained in satisfactory condition at all times. Submit list of proposed equipment to be used in the performance of construction work, including descriptive data, 7 days prior to use on the project.

1.2.1 Joint Cleaning Equipment

1.2.1.1 Concrete Saw

Provide a self-propelled power saw with water-cooled diamond saw blades for cutting joints to the depths and widths specified and for removing filler, existing old joint seal, or other material embedded in the joints or adhered to the joint faces.

1.2.1.2 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and a long-wearing venturi-type nozzle of proper size, shape, and opening. The maximum nozzle opening should not exceed 6 mm (1/4 inch). Provide a portable air compressor capable of furnishing not less than 4200 liters (150 cubic feet) per minute and maintaining a line pressure of not less than 620 kPa (90 psi) at the nozzle while in use. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint about 25 mm (1 inch) above the pavement surface and will direct the blast to clean the joint walls. Adjust the height, angle of inclination, and the size of the nozzle as necessary to ensure satisfactory results.

1.2.1.3 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, a wand with safety release cutoff controls, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary water resupply equipment shall be of sufficient capacity to permit continuous operations. The pumps, hoses, wand, and nozzle shall be of sufficient capacity to permit the cleaning of both walls of the joint and the pavement surface for a width of at least 13 mm (1/2 inch) on either side of the joint. A pressure gauge mounted at the pump shall show at all times the pressure in kPa (psi) at which the equipment is operating.

1.2.2 Sealing Equipment

Equipment used to install the compression seal shall place the compression seal to the prescribed depths within the specified tolerances without cutting, nicking, twisting, or otherwise damaging the seal. The equipment shall be capable of placing the seal with not more than two percent longitudinal stretch or compression of the seal during installation. The machine shall be an automatic self-propelled joint seal application equipment and engine powered. The machine shall include a reservoir for the lubricant/adhesive, a device for conveying the lubricant/adhesive in the proper quantities to the sides of the compression seal or the sidewalls of the joints, a reel capable of holding one full spool of compression seal, and a power-driven apparatus for feeding the joint seal through a compression device and inserting the seal into the joint. The equipment shall also include a guide to maintain the proper course along the joint being sealed. The machine shall at all times be operated by an experienced operator.

1.2.3 Test Requirements

Submit certified copies of test results, 15 days prior to use of material on the project. Each lot of compression joint seal and lubricant/adhesive shall be sampled, identified, and tested for conformance with the applicable material specification.

a. A lot of compression seal shall consist of 1 day's production. A lot of lubricant/adhesive shall consist of 1 day's production.

b. Testing of the compression joint seal and lubricant/adhesive material is the responsibility of the Contractor and shall be performed in an approved independent laboratory. Certified copies of the test reports shall be submitted for approval 15 days prior to the use of the materials at the jobsite.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment
Manufacturer's Instructions
Compression Seals
LUBRICANT/ADHESIVE

SD-06 Test Reports

Test Requirements

1.4 QUALITY ASSURANCE

1.4.1 Safety

DO NOT place compression joint seals within 7.5 meters (25 feet) of liquid oxygen (LOX) equipment, LOX storage, or LOX piping.

1.4.2 Trial Joint Seal and Lubricant/Adhesive Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 15 meters (50 feet) long at a designated location in the project pavement, using the specified materials and the approved equipment to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the trial length and before any other joint is sealed, the trial joints will be inspected by the Government to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements, remove the materials, and the joints shall be recleaned and resealed at no cost to the Government. No other joints shall be sealed until the test installation has been approved. If the trial section is approved, it may be incorporated into the permanent work. Seal other joints in the manner approved for sealing the trial joint.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials delivered to the jobsite shall be inspected for defects, unloaded, and stored with a minimum of handling to avoid damage. Provide storage facilities that protect materials from weather and maintain materials at temperatures recommended by the manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

The ambient temperature and the pavement temperature within the joint wall shall be at least 2 degrees C (35 degrees F) and rising at the time of installation of the materials. Sealant installation will not be allowed if moisture or foreign material is observed in the joint.

PART 2 PRODUCTS

2.1 COMPRESSION SEALS

Printed directions from the manufacturer on recommended installation criteria shall be furnished with the manufacturer's certification that the selected seal is recommended for the installation on this project.

Compression joint seal materials shall be a vulcanized elastomeric compound using polychloroprene as the only base polymer. The material and manufactured seal shall conform to ASTM D2628, ASTM D2628 and COE CRD-C 548 where jet fuel and/or heat blast resistance is required. The joint seal shall be a labyrinth type seal. The uncompressed depth of the face of the compression seal (that is to be bonded to the joint wall) shall be greater than the uncompressed width of the seal, except that for seals 25 mm (1 inch) or greater in width, the depth need be only 25 mm (1 inch) or greater. The actual width of the uncompressed seal for construction and contraction joints shall be 21 or 25 mm (0.75 or 1 inches) and for expansion joints shall be 32 mm (1.25 inches). The tolerance on the seal shall be plus 3 mm or minus 1.5 mm (plus 1/8 inch or minus 1/16 inch).

2.2 LUBRICANT/ADHESIVE

Lubricant/adhesive used for the compression elastomeric joint seal shall be a one-component compound conforming to ASTM D2835.

PART 3 EXECUTION

3.1 PREPARATION OF JOINTS

Immediately before installation of the compression joint seal, thoroughly clean the joints to remove laitance, filler, existing sealer, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Cleaning shall be by sandblasting or waterblasting and shall extend along pavement surfaces at least 13 mm (1/2 inch) on either side of the joint. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water. Demonstrate that the selected cleaning operation meets the cleanliness requirements. Correct any irregularity in the joint face which would prevent uniform contact between the joint seal and the joint face prior to the installation of the joint seal.

3.1.1 Sawing

Clean and open joints to the specified width and depth by sawing. Immediately following the sawing operation, thoroughly clean the joint faces and opening using a water jet to remove saw cuttings or debris remaining on the faces or in the joint opening. Install compression seal within 3 calendar days of the time the joint cavity is sawed. Depth of the joint cavity shall be in accordance with manufacturer's instructions. Where installation procedures are required in accordance with the manufacturer's recommendations, submit printed copies of manufacturers' instructions, 15 days prior to use on the project. The saw cut for the joint seal cavity shall be centered over the joint line. The nominal width of the sawed joint seal cavity shall be as follows; the actual width shall be within a tolerance of plus or minus 1.5 mm (1/16 inch):

a. If a nominal 20.6 mm (13/16 inch) wide compression seal is furnished, the nominal width of the saw cut shall be 12.7 mm (.5 inches) when the pavement temperature at the time of sawing is between -4 and 27 degrees C (25 and 80 degrees F). If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1.5 mm (1/16 inch). If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1.5 mm (1/16 inch).

b. If a nominal 25.4 mm (1 inch) wide compression seal is furnished, the nominal width of the saw cut shall be 14.3 mm (9/16 inches) when the pavement temperature at the time of sawing is between -4 and +60 degrees C (25 and 140 degrees F). If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1.5 mm (1/16) inch. If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1.5 mm (1/16 inch).

c. Measure the pavement temperature in the presence of the Contracting Officer. Make measurement each day before commencing sawing and at any other time during the day when the temperature appears to be varying from the allowable sawing range.

3.1.2 Sandblast Cleaning

Use a multiple pass sandblasting technique until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

3.1.3 Waterblast Cleaning

Use a multiple pass waterblast technique until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

3.1.4 Rate of Progress

Limit sandblasting or waterblasting of joint faces to the length of joint that can be sealed during the same workday.

3.2 INSTALLATION OF THE COMPRESSION SEAL

3.2.1 Time of Installation

Seal joints immediately within 3 calendar days of sawing the joint seal cavity and following concrete cure and the final cleaning of the joint walls. Provide open joints, ready for sealing that cannot be sealed under the specified conditions, with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, the joints shall be washed, air pressure cleaned, and allowed to dry prior to installing the lubricant/adhesive and compression seal.

3.2.2 Sequence of Installation

Seal first longitudinal joints, followed by transverse joints. Install seals in longitudinal joints so that all transverse joint seals will be intact from edge to edge of the pavement. Intersections shall be made monolithic by use of joint seal adhesive and care in fitting the intersection parts together. Extender pieces of seal shall not be used at intersections. Any seal falling short at the intersection shall be removed and replaced with new seal at no additional cost to the Government. Seals that are required to change direction by more than 20 degrees, may require a poured sealant at the intersection. Poured sealant shall be in accordance with compression seal manufacturer's instructions.

3.3 SEALING OF JOINTS

The sides of the joint seal or the sides of the joint shall be covered with a coating of lubricant/adhesive and the seal installed as specified. Butt joints and seal intersections shall be coated with liberal applications of lubricant/adhesive. Lubricant/adhesive spilled on the pavement shall be removed immediately to prevent setting on the pavement. The in-place joint seal shall be in an upright position and free from twisting, distortion, and cuts. Adjustments shall be made to the installation equipment and procedure, if the stretch exceeds 1 percent. Any seal exceeding 2 percent stretch shall be removed and replaced. The joint seal shall be placed at a uniform depth within the tolerances specified. In-place joint seal which fails to meet the specified requirements shall be removed and replaced with new joint seal at no cost to the Government. The compression joint seal shall be placed to a depth of 6 mm (1/4 inch), plus or minus 3 mm (1/8 inch), below the pavement surface except when the joint is beveled or has a radius at the surface, or unless otherwise directed. For beveled joints or joints with a radius at the surface, the compression joint seal shall be installed at a depth of 3 mm (1/8 inch), plus or minus 3 mm (1/8 inch), below the bottom of the edge of the bevel or radius. No part of the seal shall be allowed to project above the surface of the pavement or above the edge of the bevel or radius. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections to provide continuous installation of the seal in the transverse joints. The lubricant/adhesive in the longitudinal joints shall be allowed to set for 1 hour prior to cutting at the joint intersections to reduce the possibility of shrinkage. For all transverse joints, the minimum length of the compression joint seal shall be the pavement width from edge to edge.

3.4 CLEAN-UP

Upon completion of the project, remove all unused materials from the site, remove any lubricant/adhesive on the pavement surface, and leave the pavement in clean condition.

3.5 QUALITY CONTROL PROVISIONS

3.5.1 Application Equipment

Inspect the application equipment to assure uniform application of lubricant/adhesive to the sides of the compression joint seal or the walls of the joint. If any equipment causes cutting, twisting, nicking, excessive stretching or compressing of the seal, or improper application of the lubricant/adhesive, suspend the operation until causes of the deficiencies are determined and corrected.

3.5.2 Procedures

3.5.2.1 Quality Control Inspection

Provide quality control provisions during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damage the concrete in any manner. Cleaned joints shall be approved by the Government prior to installation of the lubricant/adhesive and compression joint seal.

3.5.2.2 Conformance to Stretching and Compression Limitations

Determine conformance to stretching and compression limitations. Mark the top surface of the compression seal at 305 mm (1 foot) intervals in a manner clear and durable to enable length determinations of the seal. After installation, measure the distance between the marks on the seal. If the stretching or compression exceeds 2 percent, remove the seal and replace it with new joint at no additional cost to the Government. The seal shall be removed up to the last correct measurement. The seal shall be inspected a minimum of once per 30 meters (100 feet) of seal for compliance to the shrinkage or compression requirements. Measurements shall also be made at the same interval to determine conformance with depth and width of installation requirements. Remove and replace compression seal that is not in conformance with specification requirements with new joint seal at no additional cost to the Government.

3.5.2.3 Pavement Temperature

Determine the pavement temperature by placing a thermometer in the initial saw cut for the joint and record the reading. The thermometer shall remain in the joint for an adequate time to provide a control reading.

3.5.3 Final Inspection

Inspect the joint sealing system (compression seal and lubricant/adhesive) for proper rate of cure and bonding to the concrete, cuts, twists, nicks and other deficiencies. Seals exhibiting any defects, at any time prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced in a satisfactory manner.

-- End of Section --

SECTION 32 15 00

AGGREGATE SURFACE COURSE
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D3740	(2011) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates

ASTM E11	(2009; E 2010) Wire Cloth and Sieves for Testing Purposes

KOREAN INDUSTRIAL STANDARDS (KS)

KS A 5101-1	(2004) Test sieves-Part 1: Test sieves of metal wire mesh
KS F 2302	(2002) Test Method for Particle Size Distribution of Soils
KS F 2303	(2000) Test Method for Liquid Limit and Plastic Limit of Soils
KS F 2309	(2009) Standard test method for amount of material in passing standard sieve 0.075mm in soils
KS F 2311	(2001) Test Method for Soil Density by the Sand Replacement Method
KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method
KS F 2501	(2007) Sampling Aggregate
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS F 2508	(2007) Method of test for resistance to abrasion of coarse aggregate by use of the Los Angeles machine

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment

SD-06 Test Reports

Sampling and Testing
Density Tests

1.3 QUALITY ASSURANCE

Sampling and testing is the responsibility of the Contractor. Submit calibration curves and related test results prior to using the device or equipment being calibrated. Submit copies of field test results within 24 hours after the tests are performed. Test results from samples, not less than 15 days before material is required for the work. Results of laboratory tests for quality control purposes, for approval, prior to using the material. Sampling and testing shall be performed by an approved commercial testing laboratory or by the Contractor, subject to approval. If the Contractor elects to establish its own testing facilities, approval of such facilities will be based on compliance with ASTM D3740. No work requiring testing will be permitted until the Contractor's facilities have been inspected and approved.

1.3.1 Sampling

Take samples for material gradation, liquid limit, and plastic limit tests in conformance with ASTM D75/D75M or KS F 2501. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.3.2 Testing

1.3.2.1 Gradation

Make aggregate gradation in conformance with ASTM C117, KS F 2309, ASTM C136, or KS F 2502, and ASTM D422 or KS F 2302. Sieves shall conform to ASTM E11 or KS A 5101-1.

1.3.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318 or KS F 2303.

1.3.3 Approval of Materials

Select the source of the material to be used for producing aggregates 15 days prior to the time the material will be required in the work. Approval of sources not already approved by the Corps of Engineers will be based on an inspection by the Contracting Officer. Tentative approval of materials will be based on appropriate test results on the aggregate source. Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and compacted surface course.

1.3.4 Equipment

Submit a list of proposed equipment to be used in performance of construction work including descriptive data. All plant, equipment, and tools used in the performance of the work covered by this section will be subject to approval by the Contracting Officer before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, and meeting the grade controls, thickness controls, and smoothness requirements set forth herein.

1.4 ENVIRONMENTAL REQUIREMENTS

Aggregate surface courses shall not be constructed when the ambient temperatures is below 2 degrees C (35 degrees F) and on subgrades that are frozen or contain frost. It is the responsibility of the Contractor to protect, by approved method or methods, all areas of surfacing that have not been accepted by the Contracting Officer. Surfaces damaged by freeze, rainfall, or other weather conditions shall be brought to a satisfactory condition by the Contractor.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide aggregates consisting of clean, sound, durable particles of natural gravel, crushed gravel, crushed stone, sand, slag, soil, or other approved materials processed and blended or naturally combined. Provide aggregates free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign materials. The Contractor is responsible for obtaining materials that meet the specification and can be used to meet the grade and smoothness requirements specified herein after all compaction and proof rolling operations have been completed.

2.1.1 Coarse Aggregates

The material retained on the 5 mm (No. 4) sieve shall be known as coarse aggregate. Coarse aggregates shall be reasonably uniform in density and quality. The coarse aggregate shall have a percentage of wear not to exceed 50 percent after 500 revolutions as determined by ASTM C131 or KS F 2508. The amount of flat and/or elongated particles shall not exceed 20 percent. A flat particle is one having a ratio of width to thickness greater than three; an elongated particle is one having a ratio of length to width greater than three. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the requirements set forth herein.

2.1.2 Fine Aggregates

The material passing the 5 mm (No. 4) sieve shall be known as fine aggregate. Fine aggregate shall consist of screenings, sand, soil, or other finely divided mineral matter that is processed or naturally combined with the coarse aggregate.

2.1.3 Gradation Requirements

Gradation requirements specified in TABLE I shall apply to the completed aggregate surface. It is the responsibility of the Contractor to obtain materials that will meet the gradation requirements after mixing, placing, compacting, and other operations. TABLE I shows permissible gradings for granular material used in aggregate surface roads and airfields. Sieves shall conform to ASTM E11 or KS A 5101-1.

TABLE I. GRADATION FOR AGGREGATE SURFACE COURSES
Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3	No. 4
25.0 mm	100	100	100	100
9.5 mm	50-85	60-100	--	--
4.7 mm	35-65	50-85	55-100	70-100
2.00 mm	25-50	40-70	40-100	55-100
0.425 mm	15-30	24-45	20-50	30-70
0.075 mm	8-15	8-15	8-15	8-15

TABLE I. GRADATION FOR AGGREGATE SURFACE COURSES
Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3	No. 4
1 in.	100	100	100	100
3/8 in.	50-85	60-100	--	--
No. 4	35-65	50-85	55-100	70-100
No. 10	25-50	40-70	40-100	55-100
No. 40	15-30	24-45	20-50	30-70
No. 200	8-15	8-15	8-15	8-15

2.2 LIQUID LIMIT AND PLASTICITY INDEX REQUIREMENTS

The portion of the completed aggregate surface course passing the 0.425 mm (No. 40) sieve shall have a maximum liquid limit of 35 and a plasticity index of 4 to 9.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Perform clearing, stripping, and excavating. Operate the aggregate sources to produce the quantity and quality of materials meeting these specification requirements in the specified time limit. Upon completion of the work, the aggregate sources on Government property shall be finalized to drain readily and be left in a satisfactory condition. Finalize aggregate sources on private lands in agreement with local laws or authorities.

3.2 STOCKPILING MATERIALS

Prior to stockpiling the material, clear and level the storage sites. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Stockpile aggregates in such a manner that will prevent segregation. Aggregates and binders obtained from different sources shall be stockpiled separately.

3.3 COMPACTION

Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 or KS F 2312 abbreviated herein as present laboratory maximum density. Compact each layer of the aggregate surface course with approved compaction equipment, as required in the following paragraphs. The water content during the compaction procedure shall be maintained at optimum or at the percentage specified by the Contracting Officer. In locations not accessible to the rollers, the mixture shall be compacted with mechanical tampers. Compaction shall continue until each layer through the full depth is compacted to at least 100 percent of laboratory maximum density. Remove any materials that are found to be unsatisfactory and replace them with satisfactory material or rework them to produce a satisfactory material.

3.4 PREPARATION OF UNDERLYING COURSE SUBGRADE

Clean of all foreign substances the underlying course and subgrade, including shoulders. At the time of surface course construction, the underlying course and subgrade shall contain no frozen material. Ruts or soft yielding spots in the underlying course and subgrade areas having inadequate compaction and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade and recompacting to density requirements specified in Section 32 11 16.16 SUBBASE COURSES. The completed underlying course and subgrade shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the surface course is placed.

3.5 GRADE CONTROL

During construction, the lines and grades including crown and cross slope indicated for the aggregate surface course shall be maintained by means of line and grade stakes placed by the Contractor in accordance with the SPECIAL CONTRACT REQUIREMENTS.

3.6 MIXING AND PLACING MATERIALS

The materials shall be mixed and placed to obtain uniformity of the material and a uniform optimum water content for compaction. Make adjustments in mixing, placing procedures, or in equipment to obtain the true grades, to minimize segregation and degradation, to obtain the desired water content, and to ensure a satisfactory surface course.

3.7 LAYER THICKNESS

Place the aggregate material on the underlying course and subgrade in layers of uniform thickness. When a compacted layer of 150 mm (6 inches) or less is specified, the material may be placed in a single layer; when a compacted thickness of more than 150 mm (6 inches) is required, no layer shall exceed 150 mm (6 inches) nor be less than 75 mm (3 inches) when compacted.

3.8 PROOF ROLLING

Proof rolling of the areas designated shall be in addition to compaction specified above and shall consist of application of 30 coverages with a heavy rubber-tired roller having four tires abreast with each tire loaded to 13,600 kg (30,000 pounds) and tires inflated to 1000 kPa (150 psi). In the areas designated, proof rolling shall be applied to the top lift of layer on which surface course is laid and to each layer of the base course. Water content of the lift of the layer on which the surface course is placed and each layer of the aggregate surface course shall be maintained at optimum or at the percentage directed from the start of compaction to the completion of a proof rolling. Materials in the aggregate surface course or underlying materials indicated unacceptable by the proof rolling shall be removed and replaced, as directed, with acceptable materials.

3.9 EDGES OF AGGREGATE-SURFACED ROAD

Approved material shall be placed along the edges of the aggregate surface course in such quantity as to compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least 300 mm (1 foot) of shoulder width shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the surface course.

3.10 SMOOTHNESS TEST

The surface of each layer shall not show any deviations in excess of 10 mm (3/8 inch) when tested with a 3 m (10 foot) straightedge applied both parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding this amount shall be corrected by removing material, replacing with new material, or reworking existing material and compacting, as directed.

3.11 THICKNESS CONTROL

The completed thickness of the aggregate surface course shall be within 13 mm (1/2 inch), plus or minus, of the thickness indicated on plans. The thickness of the aggregate surface course shall be measured at intervals in such manner that there will be a thickness measurement for at least each 500 square meters (yards) of the aggregate surface course. The thickness measurement shall be made by test holes at least 75 mm (3 inches) in diameter through the aggregate surface course. When the measured thickness of the aggregate surface course is more than 13 mm (1/2 inch) deficient in thickness, correct such areas by scarifying, adding mixture of proper gradation, reblading, and recompacting, as directed, at no additional expense to the Government. Where the measured thickness of the aggregate surface course is more than 13 mm (1/2 inch) thicker than that indicated, it shall be considered as conforming with the specified thickness requirements plus 13 mm (1/2 inch). The average job thickness shall be the average of the job measurements determined as specified above, but shall be within 6 mm (1/4 inch) of the thickness indicated. When the average job thickness fails to meet this criterion, make corrections by scarifying, adding or removing mixture of proper gradation, and reblading and recompacting, as directed, at no additional expense to the Government.

3.12 DENSITY TESTS

Measure density in the field in accordance with ASTM D1556 or KS F 2311, ASTM D2167 or KS F 2347,, or ASTM D6938. For the method presented in ASTM D1556 or KS F 2311 use the base plate as shown in the drawing. For the method presented in ASTM D6938 the calibration curves shall be checked and adjusted, if necessary, using only the sand cone method as described in paragraph Calibration of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals, as directed.

3.13 WEAR TEST

Perform wear tests in conformance with ASTM C131 or KS F 2508.

3.14 MAINTENANCE

Maintain the aggregate surface course in a condition that will meet all specification requirements until accepted.

-- End of Section --

SECTION 32 16 13

CONCRETE SIDEWALKS AND CURBS AND GUTTERS
04/08

PART 1 GENERAL
1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1751	(2004; E 2013; R 2013) Standard

	Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D5893/D5893M	(2010) Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2011) Steel Bars for Concrete Reinforcement
KS D 7017	(2007) Welded Steel Wire Fabrics
KS F 2401	(2007) Method of Sampling Fresh Concrete
KS F 2402	(2007) Slump of Concrete
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2449	(2002) Method of test for air content of fresh concrete by volumetric method
KS F 2538	(2005) Specification for preformed expansion joint fillers for concrete paving and structural construction
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 4007	(2002) Sheet Materials for Curing Concrete
KS T 1072	(2012) Jute Bag

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Provide plant, equipment, machines, and tools used in the work subject to approval and maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Use of the equipment shall be discontinued if it produces unsatisfactory results. The Contracting Officer shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.2.2 Slip Form Equipment

Slip form paver or curb forming machine, will be approved based on trial use on the job and shall be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in 1 pass.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

SD-06 Test Reports

Field Quality Control

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 5 degrees C (40 degrees F) and is falling, or is already below that point. Placement may begin when the air temperature reaches 2 degrees C (35 degrees F) and is rising, or is already above 5 degrees C (40 degrees F). Make provisions to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 2 degrees C (35 degrees F), placement and protection shall be approved in writing. Approval will be contingent upon full conformance with the following provisions. The underlying material shall be prepared and protected so that it is entirely free of frost when the concrete is deposited. Mixing water and aggregates shall be heated as necessary to result in the temperature of the in-place concrete being between 10 and 30 degrees C (50 and 85 degrees F). Methods and equipment for heating shall be approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 10 degrees C (50 degrees F) for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed shall not exceed 30 degrees C (85 degrees F) except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. The placing temperature shall not exceed 35 degrees C (95 degrees F) at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE except as otherwise specified. Concrete shall have a minimum compressive strength of 24 MPa (3500 psi) at 28 days. Maximum size of aggregate shall be 37.5 mm (1-1/2 inches). Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Mixtures shall have air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

The concrete slump shall be 50 mm plus or minus 25 mm (2 inches plus or minus 1 inch) where determined in accordance with ASTM C143/C143M or KS F 2402.

2.1.3 Reinforcement Steel

Reinforcement bars shall conform to ASTM A615/A615M or KS D 3504. Wire mesh reinforcement shall conform to ASTM A185/A185M or KS D 7017.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Impervious sheet materials shall conform to ASTM C171 or KS F 4007, type optional, except that polyethylene film, if used, shall be white opaque.

2.2.2 Burlap

Burlap shall conform to AASHTO M 182 or KS T 1072.

2.2.3 White Pigmented Membrane-Forming Curing Compound

White pigmented membrane-forming curing compound shall conform to ASTM C309, Type 2 or KS F 2540.

2.3 CONCRETE PROTECTION MATERIALS

Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

2.4.2 Expansion Joint Filler, Premolded

Expansion joint filler, premolded, shall conform to ASTM D1751, ASTM D1752, or KS F 2538, 13 mm (1/2 inch) thick, unless otherwise indicated.

2.5 JOINT SEALANTS

Joint sealant, cold-applied shall conform to ASTM C920 or ASTM D5893/D5893M.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete. Wood forms shall be surfaced plank, 50 mm (2 inches) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 3 m (10 feet). Radius bends may be formed with 19 mm (3/4 inch) boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Ends of steel forms shall be interlocking and self-aligning. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 3 m (10 feet) with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.1 Sidewalk Forms

Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

2.6.2 Curb and Gutter Forms

Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 3 m (10 feet) or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 38 mm (1-1/2 inch) benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

The subgrade shall be constructed to the specified grade and cross section prior to concrete placement. Subgrade shall be placed and compacted in conformance with Section 31 00 00 EARTHWORK.

3.1.1 Sidewalk Subgrade

The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected to produce a subgrade free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 1.2 m (4 feet). Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly and satisfactorily repaired. Forms shall be cleaned and coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 3 mm (1/8 inch) in any 3 m (10 foot) long section. After forms are set, grade and alignment shall be checked with a 3 m (10 foot) straightedge. Forms shall have a transverse slope as indicated of 20 mm per meter (1/4 inch per foot) with the low side adjacent to the roadway. Side forms shall not be removed for 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished, as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks shall be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be consolidated by tamping and spading or with an approved vibrator, and the surface shall be finished to grade with a strike off.

3.3.2 Concrete Finishing

After straight edging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

All slab edges, including those at formed joints, shall be finished with an edger having a radius of 3 mm (1/8 inch). Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.3.4 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 8 mm (5/16 inch) from the testing edge of a 3 m (10-foot) straightedge. Permissible deficiency in section thickness will be up to 6 mm (1/4 inch).

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Concrete shall be placed to the section required in a single lift. Consolidation shall be achieved by using approved mechanical vibrators. Curve shaped gutters shall be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 13 mm (1/2 inch). Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float.

3.4.4 Joint Finishing

Curb edges at formed joints shall be finished as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 6 mm (1/4 inch) from the testing edge of a 3 m (10-foot) straightedge. Permissible deficiency in section thickness will be up to 6 mm (1/4 inch).

3.5 SIDEWALK JOINTS

Sidewalk joints shall be constructed to divide the surface into rectangular areas. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 1.5 m (5 feet) on centers, whichever is less, and shall be continuous across the slab. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 3 m (10 feet) or more in width. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 3 mm (1/8 inch) blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Expansion joints shall be formed with 13 mm (1/2 inch) joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Joint filler shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 3 mm (1/8 inch), and concrete over the joint filler shall be removed. At the end of the curing period, expansion joints shall be cleaned and filled with cold-applied joint sealant. Joint sealant shall be gray or stone in color. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C (50 degrees F) at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.5.3 Reinforcement Steel Placement

Reinforcement steel shall be accurately and securely fastened in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Contraction joints shall be constructed directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 1.5 m (5 feet) nor greater than 4.5 m (15 feet) in length.

a. Contraction joints (except for slip forming) shall be constructed by means of 3 mm (1/8 inch) thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

b. When slip forming is used, the contraction joints shall be cut in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. The depth of cut shall be at least one-fourth of the gutter/curb depth and 3 mm (1/8 inch) in width.

3.6.2 Expansion Joints

Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement, and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, expansion joints at least 13 mm (1/2 inch) in width shall be provided at intervals not less than 10 meters (30 feet) nor greater than 36 meters (120 feet). Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated. Expansion joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS. Expansion joints and the top 25 mm (1 inch) depth of curb and gutter contraction-joints shall be sealed with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C (50 degrees F) at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

The entire exposed surface shall be covered with 2 or more layers of burlap. Mats shall overlap each other at least 150 mm (6 inches). The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 300 mm (12 inches) when a continuous sheet is not used. The curing medium shall not be less than 450 mm (18-inches) wider than the concrete surface to be cured, and shall be securely weighted down by heavy wood planks, or a bank of moist earth placed along edges and laps in the sheets. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water and the curing compound applied as soon as the free water disappears. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage of approximately 5 square meters/L (200 square feet/gallon) for the total of both coats. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed. Necessary precautions shall be taken to insure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period. Approved standby facilities for curing concrete pavement shall be provided at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Completed concrete shall be protected from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.7.4 Protective Coating

Protective coating, of linseed oil mixture, shall be applied to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Concrete to receive a protective coating shall be moist cured.

3.7.4.1 Application

Curing and backfilling operation shall be completed prior to applying two coats of protective coating. Concrete shall be surface dry and clean before each application. Coverage shall be by spray application at not more than 11 square meters/L (50 square yards/gallon) for first application and not more than 15.5 square meters/L (70 square yards/gallon) for second application, except that the number of applications and coverage for each application for commercially prepared mixture shall be in accordance with the manufacturer's instructions. Coated surfaces shall be protected from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Protective coating shall not be heated by direct application of flame or electrical heaters and shall be protected from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Material shall not be applied at ambient or material temperatures lower than 10 degrees C (50 degrees F).

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and any additional tests to insure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken at least once a day or once for every 190 cubic meters (250 cubic yards) of concrete, whichever is more frequent. The samples for strength tests shall be taken in accordance with ASTM C172/C172M or KS F 2401. Cylinders for acceptance shall be molded in conformance with ASTM C31/C31M by an approved testing laboratory. Each strength test result shall be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 4 MPa (500 psi).

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M, KS F 2449, ASTM C231/C231M, or KS F 2421. ASTM C231/C231M or KS F 2421 shall be used with concretes and mortars made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. If results are out of tolerance, the placing foreman shall be notified and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Two slump tests shall be made on randomly selected batches of each class of concrete for every 190 cubic meters (250 cubic yards), or fraction thereof, of concrete placed during each shift. Additional tests shall be performed when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 6 mm (1/4 inch) the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 6 mm (1/4 inch). Pavement areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Government and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

-- End of Section --

SECTION 32 17 24.00 10

PAVEMENT MARKINGS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 247	(2011) Standard Specification for Glass Beads Used in Pavement Markings

ASTM INTERNATIONAL (ASTM)

ASTM D4280	(2008) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers
ASTM D4505	(2005) Preformed Retroflective Pavement Marking Tape for Extended Service Life
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM E28	(1999; R 2009) Softening Point of Resins Derived from Naval Stores by Ring and Ball Apparatus

KOREAN INDUSTRIAL STANDARDS (KS)

KS M 3016	(2006) Testing method of the density and specific gravity for plastics

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325	(Rev D) Beads (Glass Spheres) Retro-Reflective (Metric)
FS TT-P-1952	(Rev E) Paint, Traffic and Airfield Markings, Waterborne

1.2 SYSTEM DESCRIPTION

All machines, tools and equipment used in the performance of the work shall be approved and maintained in satisfactory operating condition. Submit lists of proposed equipment, including descriptive data, and notifications of proposed Contractor actions as specified in this section. List of removal equipment shall include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Equipment operating on roads and runways shall display low speed traffic markings and traffic warning lights.

1.2.1 Paint Application Equipment

1.2.1.1 Self-Propelled or Mobile-Drawn Pneumatic Spraying Machines

The equipment to apply paint to pavements shall be a self-propelled or mobile-drawn pneumatic spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. The machine shall have a speed during application not less than 8 km/hour (5 mph), and shall be capable of applying the stripe widths indicated, at the paint coverage rate specified in paragraph APPLICATION, and of even uniform thickness with clear-cut edges. Equipment used for marking streets and highways shall be capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines or a combination of solid and intermittent lines using a maximum of two different colors of paint as specified. The equipment used to apply the paint binder to airfield pavements shall be a self-propelled or mobile-drawn pneumatic spraying machine with an arrangement of atomizing nozzles capable of applying a line width at any one time in multiples of 150 mm (6 inches), from 150 mm (6 inches) to 900 mm (36 inches). The paint applicator shall have paint reservoirs or tanks of sufficient capacity and suitable gauges to apply paint in accordance with requirements specified. Tanks shall be equipped with suitable air-driven mechanical agitators. The spray mechanism shall be equipped with quick-action valves conveniently located, and shall include necessary pressure regulators and gauges in full view and reach of the operator. Paint strainers shall be installed in paint supply lines to ensure freedom from residue and foreign matter that may cause malfunction of the spray guns. The paint applicator shall be readily adaptable for attachment of an air-actuated dispenser for the reflective media approved for use. Pneumatic spray guns shall be provided for hand application of paint in areas where the mobile paint applicator cannot be used.

1.2.1.2 Hand-Operated, Push-Type Machines

All machines, tools, and equipment used in performance of the work shall be approved and maintained in satisfactory operating condition. Hand-operated push-type machines of a type commonly used for application of paint to pavement surfaces will be acceptable for marking small streets and parking areas. Applicator machine shall be equipped with the necessary paint tanks and spraying nozzles, and shall be capable of applying paint uniformly at coverage specified. Sandblasting equipment shall be provided as required for cleaning surfaces to be painted. Hand-operated spray guns shall be provided for use in areas where push-type machines cannot be used.

1.2.2 Thermoplastic Application Equipment

1.2.2.1 Thermoplastic Material

Thermoplastic material shall be applied to the primed pavement surface by spray techniques or by the extrusion method, wherein one side of the shaping die is the pavement and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of material. By either method, the markings shall be applied with equipment that is capable of providing continuous uniformity in the dimensions of the stripe.

1.2.2.2 Application Equipment

a. Application equipment shall provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the extrusion shoe or spray gun shall prevent accumulation and clogging. All parts of the equipment which come into contact with the material shall be easily accessible and exposable for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns shall maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.

b. The application equipment shall be constructed to ensure continuous uniformity in the dimensions of the stripe. The applicator shall provide a means for cleanly cutting off stripe ends squarely and shall provide a method of applying "skiplines". The equipment shall be capable of applying varying widths of traffic markings.

c. The applicator shall be equipped with a drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser shall be automatically operated and shall begin flow prior to the flow of composition to assure that the strip is fully reflectorized.

1.2.2.3 Mobile and Maneuverable

Application equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment used for the placement of thermoplastic pavement markings shall be of two general types: mobile applicator and portable applicator.

a. Mobile Application Equipment: The mobile applicator shall be defined as a truck-mounted, self-contained pavement marking machine that is capable of hot applying thermoplastic by either the extrusion or spray method. The unit shall be equipped to apply the thermoplastic marking material at temperatures exceeding 190 degrees C (375 degrees F), at widths varying from 75 to 300 mm (3 to 12 inches) and in thicknesses varying from 1.0 to 5.0 mm (0.020 to 0.190 inch) and shall have an automatic drop-on bead system. The mobile unit shall be capable of operating continuously and of installing a minimum of 6 km (20,000 lineal feet) of longitudinal markings in an 8-hour day.

   (1) The mobile unit shall be equipped with a melting kettle which holds a minimum of 2.7 metric tons (6000 pounds) of molten thermoplastic material. The kettle shall be capable of heating the thermoplastic composition to temperatures of 195 to 220 degrees C (375 to 425 degrees F). A thermostatically controlled heat transfer liquid shall be used. Heating of the composition by direct flame will not be allowed. Oil and material temperature gauges shall be visible at both ends of the kettle. The mobile unit shall be equipped with a minimum of two extrusion shoes located one on each side of the truck, and shall be capable of marking simultaneous edgeline and centerline stripes. Each extrusion shoe shall be a closed, oil-jacketed unit; shall hold the molten thermoplastic at a temperature of 195 to 220 degrees C (375 to 425 degrees F); and shall be capable of extruding a line of 75 to 200 mm (3 to 8 inches) in width; and at a thickness of not

less than 3 mm (0.125 inch) nor more than 5.0 mm (0.190 inch), and of generally uniform cross section. The mobile unit shall be equipped with a spray gun system. The spray system shall consist of a minimum of four spray guns, located two on each side of the truck, and shall be capable of marking simultaneous edgeline and centerline stripes. The spray system shall be surrounded (jacketed) with heating oil to maintain the molten thermoplastic at a temperature of 195 to 220 degrees C (375 to 425 degrees F); and shall be capable of spraying a stripe of 75 to 300 mm (3 to 12 inches) in width, and in thicknesses varying from 1.5 mm (0.055 inch) to 2.5 mm (0.095 inch), and of generally uniform cross section.

(2) The mobile unit shall be equipped with an electronic programmable line pattern control system. The control system shall be capable of applying skip or solid lines in any sequence, through any and all of the extrusion shoes, or the spray guns, and in programmable cycle lengths. In addition, the mobile unit shall be equipped with an automatic counting mechanism capable of recording the number of lineal meters (feet) of thermoplastic markings applied to the pavement surface with an accuracy of 0.5 percent.

b. Portable Application Equipment: The portable applicator shall be defined as hand-operated equipment, specifically designed for placing special markings such as crosswalks, stopbars, legends, arrows, and short lengths of lane, edge and centerlines. The portable applicator shall be capable of applying thermoplastic pavement markings by the extrusion method. The portable applicator shall be loaded with hot thermoplastic composition from the melting kettles on the mobile applicator. The portable applicator shall be equipped with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, so as to be capable of holding the molten thermoplastic at a temperature of 195 to 220 degrees C (375 to 425 degrees F), of extruding a line of 75 to 300 mm (3 to 12 inches) in width, and in thicknesses of not less than 3.0 mm (0.125 inch) nor more than 5.0 mm (0.190 inch) and of generally uniform cross section.

1.2.3 Reflective Media Dispenser

The dispenser for applying the reflective media shall be attached to the paint dispenser and shall operate automatically and simultaneously with the applicator through the same control mechanism. The dispenser shall be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION, at all operating speeds of the applicator to which it is attached.

1.2.4 Preformed Tape Application Equipment

Mechanical application equipment shall be used for the placement of preformed marking tape. Mechanical application equipment shall be defined as a mobile pavement marking machine specifically designed for use in applying precoated, pressure-sensitive pavement marking tape of varying widths, up to 300 mm (12 inches). The applicator shall be equipped with rollers, or other suitable compactive device, to provide initial adhesion of the preformed, pressure-sensitive marking tape with the pavement surface. Additional hand-operated rollers shall be used as required to properly seat the thermoplastic tape.

1.2.5 Surface Preparation Equipment

1.2.5.1 Sandblasting Equipment

Sandblasting equipment shall include an air compressor, hoses, and nozzles of proper size and capacity as required for cleaning surfaces to be painted. The compressor shall be capable of furnishing not less than 70.8 L/sec (150 cfm) of air at a pressure of not less than 620 kPa (90 psi) at each nozzle used, and shall be equipped with traps that will maintain the compressed air free of oil and water.

1.2.5.2 Waterblast Equipment

The water pressure shall be specified at 17.9 MPa (2600 psi) at 60 degrees C (140 degrees F) in order to adequately clean the surfaces to be marked.

1.2.6 Marking Removal Equipment

Equipment shall be mounted on rubber tires and shall be capable of removing markings from the pavement without damaging the pavement surface or joint sealant. Waterblasting equipment shall be capable of producing an adjustable, pressurized stream of water. Sandblasting equipment shall include an air compressor, hoses, and nozzles. The compressor shall be equipped with traps to maintain the air free of oil and water.

1.2.6.1 Shotblasting Equipment

Shotblasting equipment shall be capable of producing an adjustable depth of removal of marking and pavement. Each unit shall be self-cleaning and self-contained, shall be able to confine dust and debris from the operation, and shall be capable of recycling the abrasive for reuse.

1.2.6.2 Chemical Equipment

Chemical equipment shall be capable of application and removal of chemicals from the pavement surface, and shall leave only non-toxic biodegradable residue.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment; G
PAINT
THERMOPLASTIC COMPOUNDS
Asphalt Concrete Primer
REFLECTIVE MEDIA

SD-06 Test Reports

Sampling and Testing

SD-07 Certificates

Qualifications
Volatile Organic Compound (VOC)

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of chemicals.

1.4.2 Traffic Controls

Suitable warning signs shall be placed near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Small markers shall be placed along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Painting equipment shall be marked with large warning signs indicating slow-moving painting equipment in operation.

1.4.3 Maintenance of Traffic

1.4.3.1 Airfield

The performance of work in the controlled zones of airfields shall be coordinated with the Contracting Officer and with the Flight Operations Officer. Verbal communications shall be maintained with the control tower before and during work in the controlled zones of the airfield. The control tower shall be advised when the work is completed. A radio for this purpose shall be provided by the Contractor and approved by the Contracting Officer.

1.4.3.2 Roads, Streets, and Parking Areas

When traffic must be rerouted or controlled to accomplish the work, the necessary warning signs, flag persons, and related equipment for the safe passage of vehicles shall be provided.

1.5 DELIVERY, STORAGE, AND HANDLING

All materials shall be delivered and stored in sealed containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, manufacturer's name, and directions, all of which shall be plainly legible at time of use.

1.6 ENVIRONMENTAL REQUIREMENTS

Pavement surface shall be free of snow, ice, or slush. Surface temperature shall be at least 5 degrees C (40 degrees F) and rising at the beginning of operations, except those involving shot or sand blasting. Operation shall cease during thunderstorms. Operation shall cease during rainfall, except for waterblasting and removal of previously applied chemicals. Waterblasting shall cease where surface water accumulation alters the effectiveness of material removal.

PART 2 PRODUCTS

2.1 PAINT

The paint shall be homogeneous, easily stirred to smooth consistency, and shall show no hard settlement or other objectionable characteristics during a storage period of 6 months. Paints for airfields, roads, parking areas, and streets shall conform to FS TT-P-1952, color as indicated on the contract drawings. Pavement marking paints shall comply with applicable ROK national, provincial, and and local laws.

2.2 THERMOPLASTIC COMPOUNDS

The thermoplastic reflectorized pavement marking compound shall be extruded or sprayed in a molten state onto a primed pavement surface. Following a surface application of glass beads and upon cooling to normal pavement temperatures, the marking shall be an adherent reflectorized strip of the specified thickness and width that is capable of resisting deformation by traffic.

2.2.1 Composition Requirements

Submit Manufacturer's current printed product description and Material Safety Data Sheets (MSDS) for each type paint/color proposed for use. The binder component shall be formulated as a hydrocarbon resin. The pigment, beads and filler shall be uniformly dispersed in the binder resin. The thermoplastic composition shall be free from all skins, dirt, and foreign objects and shall comply with the following requirements:

Component	Percent by Weight	
	White	Yellow
Binder	17 min.	17 min.
Titanium dioxide	10 min.	-
Glass beads	20 min.	20 min.
Calcium carbonate and inert fillers	49 max.	*
Yellow pigments	-	*
*Amount and type of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing the other composition requirements of this specification are met.		

2.2.2 Physical Properties

2.2.2.1 Color

The color shall be as indicated on the drawings.

2.2.2.2 Drying Time

When installed at 20 degrees C (70 degrees F) and in thicknesses between 3 and 5 mm (1/8 and 3/16 inch), after curing 15 minutes.

2.2.2.3 Softening Point

The composition shall have a softening point of not less than 90 degrees C (194 degrees F) when tested in accordance with ASTM E28.

2.2.2.4 Specific Gravity

The specific gravity of the composition shall be between 1.9 and 2.2 as determined in accordance with ASTM D792 or KS M 3016, Method A.

2.2.3 Asphalt Concrete Primer

The primer for asphalt concrete pavements shall be a thermosetting adhesive with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved and/or dispersed in a volatile organic compound (VOC). Submit certificate stating that the proposed pavement marking paint meets the VOC regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located. Solids content shall not be less than 10 percent by weight at 20 degrees C (70 degrees F) and 60 percent relative humidity. A wet film thickness of 0.10 mm (0.005 inch) plus or minus 0.025 mm (0.001 inch), shall dry to a tack-free condition in less than 5 minutes.

2.2.4 Portland Cement Concrete Primer

The primer for Portland cement concrete pavements shall be an epoxy resin primer. The primer shall be of the type recommended by the manufacturer of the thermoplastic composition. Epoxy primers recommended by the manufacturer shall be approved by the Contracting Officer prior to use. Requests for approval shall be accompanied with technical data, instructions for use, and a 1 liter (1 quart) sample of the primer material.

2.3 PREFORMED TAPE

The preformed tape shall be an adherent reflectorized strip in accordance with ASTM D4505 Type I or IV, Class optional.

2.4 RAISED REFLECTIVE MARKERS

Either metallic or nonmetallic markers of the button or prismatic reflector type may be used. Markers shall be of permanent colors, as specified for pavement marking, and shall retain the color and brightness under the action of traffic. Button markers shall have a diameter of not less than 100 mm (4 inches), and shall be spaced not more than 12 meters (40 feet) apart on solid longitudinal lines. Broken centerline marker spacings shall be in segments indicated with gaps indicated between segments. Markers shall have rounded surfaces presenting a smooth contour to traffic and shall not project more than 19 mm (3/4 inch) above level of pavement. Pavement markers and adhesive epoxy shall conform to ASTM D4280.

2.5 REFLECTIVE MEDIA

Reflective media for airfields shall conform to FS TT-B-1325, Type I, Gradation A. Reflective media for roads and streets shall conform to FS TT-B-1325, Type I, Gradation A or AASHTO M 247, Type I.

2.6 SAMPLING AND TESTING

Materials proposed for use shall be stored on the project site in sealed and labeled containers, or segregated at source of supply, sufficiently in advance of needs to allow 60 days for testing. Submit certified copies of the test reports, prior to the use of the materials at the jobsite. Testing shall be performed in an approved independent laboratory. Upon notification by the Contractor that the material is at the site or source of supply, a sample shall be taken by random selection from sealed containers in the presence of the Contracting Officer. Samples shall be clearly identified by designated name, specification number, batch number, manufacturer's formulation number, project contract number, intended use, and quantity involved.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Thoroughly clean surfaces to be marked before application of the pavement marking material. Dust, dirt, and other granular surface deposits shall be removed by sweeping, blowing with compressed air, rinsing with water or a combination of these methods as required. Rubber deposits, surface laitance, existing paint markings, and other coatings adhering to the pavement shall be completely removed with scrapers, wire brushes, sandblasting, approved chemicals, or mechanical abrasion as directed. Areas of old pavement affected with oil or grease shall be scrubbed with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinsed thoroughly after each application. After cleaning, oil-soaked areas shall be sealed with cut shellac to prevent bleeding through the new paint. Pavement surfaces shall be allowed to dry, when water is used for cleaning, prior to striping or marking. Surfaces shall be recleaned, when work has been stopped due to rain.

3.1.1 Pretreatment for Early Painting

Where early painting is required on rigid pavements, apply a pretreatment with an aqueous solution, containing 3 percent phosphoric acid and 2 percent zinc chloride, to prepared pavement areas prior to painting.

3.1.2 Cleaning Existing Pavement Markings

In general, markings shall not be placed over existing pavement marking patterns. Remove existing pavement markings, which are in good condition but interfere or conflict with the newly applied marking patterns. Deteriorated or obscured markings that are not misleading or confusing or interfere with the adhesion of the new marking material do not require removal. New preformed and thermoplastic pavement markings shall not be applied over existing preformed or thermoplastic markings. Whenever grinding, scraping, sandblasting or other operations are performed the work must be conducted in such a manner that the finished pavement surface is not damaged or left in a pattern that is misleading or confusing. When these operations are completed the pavement surface shall be blown off with compressed air to remove residue and debris resulting from the cleaning work.

3.1.3 Cleaning Concrete Curing Compounds

On new portland cement concrete pavements, cleaning operations shall not begin until a minimum of 30 days after the placement of concrete. All new concrete pavements shall be cleaned by either sandblasting or water blasting. When water blasting is performed, thermoplastic and preformed markings shall be applied no sooner than 24 hours after the blasting has been completed. The extent of the blasting work shall be to clean and prepare the concrete surface as follows:

a. There is no visible evidence of curing compound on the peaks of the textured concrete surface.

b. There are no heavy puddled deposits of curing compound in the valleys of the textured concrete surface.

c. All remaining curing compound is intact; all loose and flaking material is removed.

d. The peaks of the textured pavement surface are rounded in profile and free of sharp edges and irregularities.

e. The surface to be marked is dry.

3.2 APPLICATION

All pavement markings and patterns shall be placed as shown on the plans.

3.2.1 Paint

Paint shall be applied to clean, dry surfaces, and only when air and pavement temperatures are above 5 degrees C (40 degrees F) and less than 35 degrees C (95 degrees F). Paint temperature shall be maintained within these same limits. New asphalt pavement surfaces and new Portland concrete cement shall be allowed to cure for a period of not less than 30 days before applications of paint. Paint shall be applied pneumatically with approved equipment at rate of coverage specified. Provide guide lines and templates as necessary to control paint application. Special precautions shall be taken in marking numbers, letters, and symbols. Edges of markings shall be sharply outlined.

3.2.1.1 Rate of Application

a. Reflective Markings: Pigmented binder shall be applied evenly to the pavement area to be coated at a rate of 2.6 plus or minus 0.1 square meter/L (105 plus or minus 5 square feet/gallon). Glass spheres shall be applied uniformly to the wet paint on airfield pavement at a rate of 1.0 (8) on road and street pavement at a rate of 0.7 (6) plus or minus 0.06 kg (0.5 pounds) of glass spheres per L (gallon) of paint.

b. Nonreflective Markings: Paint shall be applied evenly to the pavement surface to be coated at a rate of 2.6 plus or minus 0.1 square meter/L (105 plus or minus 5 square feet/gallon).

3.2.1.2 Drying

The maximum drying time requirements of the paint specifications will be strictly enforced to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. If there is a delay in drying of the markings, painting operations shall be discontinued until cause of the slow drying is determined and corrected.

3.2.2 Thermoplastic Compounds

Thermoplastic pavement markings shall be placed upon dry pavement; surface dry only will not be considered an acceptable condition. At the time of installation, the pavement surface temperature shall be a minimum of 5 degrees C (40 degrees F) and rising. Thermoplastics, as placed, shall be free from dirt or tint.

3.2.2.1 Longitudinal Markings

All centerline, skipline, edgeline, and other longitudinal type markings shall be applied with a mobile applicator. All special markings, crosswalks, stop bars, legends, arrows, and similar patterns shall be placed with a portable applicator, using the extrusion method.

3.2.2.2 Primer

After surface preparation has been completed the asphalt and/or concrete pavement surface shall be primed. The primer shall be applied with spray equipment. Primer materials shall be allowed to "set-up" prior to applying the thermoplastic composition. The asphalt concrete primer shall be allowed to dry to a tack-free condition, usually occurring in less than 10 minutes. The Portland cement concrete primer shall be allowed to dry in accordance with the thermoplastic manufacturer's recommendations. To shorten the curing time of the epoxy resins an infrared heating device may be used on the concrete primer.

a. Asphalt Concrete Primer: Primer shall be applied to all asphalt concrete pavements at a wet film thickness of 0.10 mm (0.005 inch), plus or minus 0.025 mm (0.001 inch) (25-40 square meters/L (265-400 square feet/gallon)).

b. Portland Cement Concrete Primer: Primer shall be applied to all concrete pavements (including concrete bridge decks) at a wet film thickness of between 1.0 to 1.3 mm (0.04 to 0.05 inch) (30-40 square meters/L (320-400 square feet/gallon)).

3.2.2.3 Markings

After the primer has "set-up", the thermoplastic shall be applied at temperatures no lower than 190 degrees C (375 degrees F) nor higher than 220 degrees C (425 degrees F) at the point of deposition. Immediately after installation of the marking, drop-on glass spheres shall be mechanically applied so that the spheres are held by and imbedded in the surface of the molten material.

a. Extruded Markings: All extruded thermoplastic markings shall be applied at the specified width and at a thickness of not less than 3.0 mm (0.125 inch) nor more than 5.0 mm (0.190 inch).

b. Sprayed Markings: All sprayed thermoplastic markings shall be applied at the specified width and the thicknesses designated in the contract plans. If the plans do not specify a thickness, centerline markings shall be applied at a wet thickness of 2.0 mm (0.090 inch), plus or minus 0.10 mm (0.005 inch), and edgeline markings at a wet thickness of 1.5 mm (0.060 inch) plus or minus 0.10 mm (0.005 inch).

c. Reflective Glass Spheres: Immediately following application, reflective glass spheres shall be dropped onto the molten thermoplastic marking at the rate of 1 kg/2 square meters (1 pound/20 square feet) of compound.

3.2.3 Preformed Tape

The pavement surface temperature shall be a minimum of 15 degrees C (60 degrees F) and the ambient temperature shall be a minimum of 15 degrees C (60 degrees F) and rising. The preformed markings shall be placed in accordance with the manufacturer's written instructions.

3.2.4 Raised Reflective Markers

Prefabricated markers shall be aligned carefully at the required spacing and permanently fixed in place by means of epoxy resin adhesives. To insure good bond, pavement in areas where markers will be set shall be thoroughly cleaned by sandblasting and use of compressed air prior to applying adhesive.

3.2.5 Reflective Media

Application of reflective media shall immediately follow application of pigmented binder. Drop-on application of glass spheres shall be accomplished to insure that reflective media is evenly distributed at the specified rate of coverage. Should there be malfunction of either paint applicator or reflective media dispenser, operations shall be discontinued immediately until deficiency is corrected.

3.3 MARKING REMOVAL

Pavement marking, including plastic tape, shall be removed in the areas shown on the drawings. Removal of marking shall be as complete as possible without damage to the surface. Aggregate shall not be exposed by the removal process. After the markings are removed, the cleaned pavement surfaces shall exhibit adequate texture for remarking as specified in paragraph SURFACE PREPARATION. Demonstrate removal of pavement marking in an area designated by the Contracting Officer. The demonstration area will become the standard for the remainder of the work.

3.3.1 Equipment Operation

Equipment shall be controlled and operated to remove markings from the pavement surface, prevent dilution or removal of binder from underlying pavement, and prevent emission of blue smoke from asphalt or tar surfaces.

3.3.2 Cleanup and Waste Disposal

The worksite shall be kept clean of debris and waste from the removal operations. Cleanup shall immediately follow removal operations in areas subject to air traffic. Debris shall be disposed of at approved sites.

-- End of Section --

SECTION 32 18 16.13

PLAYGROUND PROTECTIVE SURFACING
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2047	(2011) Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
ASTM D2261	(2011) Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant Rate-of-Extension Tensile Testing Machine)
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D6112	(2010) Compressive and Flexural Creep and Creep-Rupture of Plastic Lumber and Shapes
ASTM D648	(2007) Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
ASTM E1912	(1998; R 2004) Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases
ASTM F1015	(2003; R 2009) Relative Abrasiveness of Synthetic Turf Playing Surfaces
ASTM F1292	(2009) Impact Attenuation of Surface Systems Under and Around Playground Equipment
ASTM F1487	(2011) Playground Equipment for Public Use

CONSUMER PRODUCT SAFETY COMMISSION (CPSC)

CPSC Pub No 325	(1997) Handbook for Public Playground Safety

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F 2502	(2014) Standard test method for sieve analysis of fine and coarse aggregates
KS K 0536	(2009) Test method for tearing strength of cloth: Tongue method

1.2 DEFINITIONS

1.2.1 Critical Height

The fall height at which the protective surfacing meets the requirements of ASTM F1292.

1.2.2 Designated Play Surface

Any elevated surface for standing, walking, sitting, or climbing; or a flat surface a minimum 50 mm (2 inches) wide having up to a maximum 30 degree angle from horizontal. In some play events the platform surface will be the same as the designated play surface. However, the terms should not be interchanged as they do not define the same point of measurement according to ASTM F1487.

1.2.3 Head Injury Criteria (HIC)

A measure of impact severity that considers the duration over which the most critical section of the deceleration pulse persists as well as the peak level of that deceleration. Head impact injuries are not believed to be life threatening if the HIC does not exceed a value of 1,000.

1.2.4 Impact Attenuation

The ability of protective surfacing to reduce and dissipate the energy of an impacting body.

1.2.5 Loose Fill

Consisting of small independent movable components such as sand, gravel, or wood chip. The percent of fine material in the loose fill affects its compression properties from rainfall.

1.2.6 Maximum Equipment Height

The highest point on the equipment (i.e.: roof ridge, top of support pole).

1.2.7 Play Event

A piece of manufactured playground equipment that supports one or more play activities.

1.3 SYSTEM DESCRIPTION

Measure the perimeters of the play event use zone in accordance with the requirements of Section 11 68 13 PLAYGROUND EQUIPMENT.

1.3.1 Child Safety

Meet or exceed the impact attenuating performance requirements of synthetic surfacing and loose-fill surfacing systems, installed in the use zones, as follows. The surfacing critical height value shall yield up to both a maximum 200 G's peak deceleration, and a maximum 1,000 Head Injury Criteria (HIC) value for a head-first fall from the play event in accordance with CPSC Pub No 325 and ASTM F1292. The protective surfacing should have a minimum critical height value equal to the height of the highest designated play surface. Measuring fall heights for play events is defined in paragraph FALL HEIGHT. Sand, gravel, and wood products shall not be installed over a concrete or bituminous subsurface in accordance with CPSC Pub No 325.

1.3.2 Child Accessibility

The accessibility requirement in accordance with ASTM F1487 includes the following: When the play event use zone consists of a protective surfacing rated as inaccessible, at least one accessible route shall be provided from the use zone perimeter to the play event. When there is more than one of the same play activity provided, only one shall meet accessibility requirements (i.e.: one swing seat or one spring rocking play event). When the access and egress points are not the same for a play event, an accessible route shall be provided to both. The accessible route shall access all accessible play events and elements. The protective surfacing that meet accessibility are synthetic surfacing and engineered wood fiber in accordance with ASTM E1912. When the accessible surface is within the use zone, it shall meet the requirements of paragraph CHILD SAFETY

1.3.3 Play Areas at CDC

The technical representative for outdoor play areas at CDC shall be the installation Child Development Services (CDS) Coordinator. The design of the CDC outdoor play area shall be based on the developmental play program for the age groups accommodated at the CDC. The play area is designed to support the CDC program and to provide a stage set for creative play. Developmental activities are selected which promote the intellectual, social, emotional and physical growth of the children. The developmental play program is developed by the MACOM CDS Director, installation CDS Coordinator and CDC Director. They are responsible for the developmental play program, child safety and accessibility to meet that program.

1.3.4 Sites Other than CDC

The technical representative for outdoor play areas on sites other than Child Development Centers (CDC) shall be the Director of Public Works or designated representative. The design of these outdoor play areas shall be based on the play program and the age groups to be accommodated as determined by the play area committee.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings.
Finished Grade and Underground Utilities

SD-03 Product Data

Synthetic Surfacing
Loose Fill Surfacing
Loose Fill Surfacing system
Geotextile Fabric
Manufacturer's Qualification
Wood
Site Preparation
Temperature Limitation
Wood By-Products
Wood Treatment
Adhesive
Color

SD-06 Test Reports

Percolation Test
Recycled Plastic
Synthetic Surfacing
Sand
Gravel

SD-07 Certificates

Materials
Manufacturer's Qualification
Manufacturer's Representative
Installer's Qualification
Substitution
Protective Surfacing Acceptance

SD-10 Operation and Maintenance Data

Maintenance Instructions

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer's Qualification

Submit name of the owner or user; service or preventive maintenance provider; date of the installation; point of contact and telephone number; and address for 10 sites. Protective surfacing should have been installed in a minimum 10 sites and been in successful service for a minimum 5 year calendar period. The manufacturer shall provide a Certificate of Insurance AA rated for a minimum one million dollars covering both product and general liability.

1.5.2 Manufacturer's Representative

Submit the individual's name, company name and address, and playground safety training certificate. The manufacturer's certified playground safety inspector or the manufacturer's designated certified playground safety representative shall supervise the installation and adjustment of the protective surfacing to verify the installation meets the requirements of the manufacturer, this specification, and paragraphs CHILD SAFETY and CHILD ACCESSIBILITY.

1.5.3 Installer's Qualification

Submit the installer's company name and address, training and experience certification. The installer shall be certified by the manufacturer for training and experience installing the protective surfacing.

1.5.4 Shop Drawings

When the use zone perimeter and play event configuration conflict with the requirements and paragraphs CHILD SAFETY and CHILD ACCESSIBILITY, submit scale drawings defining corrective measures to include the following: Adjustment to the play event with the use zone perimeter; use zone perimeter overlaps; fall height and critical height value.

1.6 DELIVERY, STORAGE, AND HANDLING

Provide a delivery schedule at least 10 calendar days prior to the first day of delivery. Deliver, handle, and store protective surfacing material in accordance with the manufacturer's recommendations. The storage area shall be as designated. Store the materials in a dry, covered area until installed. Inspect protective surfacing material, upon arrival at the job site, for meeting specified quality. Unacceptable materials shall be removed from the job site.

1.7 WARRANTY

Furnish protective surfacing with a minimum 1 year calendar period warranty.

1.8 MAINTENANCE INSTRUCTIONS

Submit 1 bound copy & one digital copy (.pdf - text searchable) of the manufacturer's operation and maintenance manual describing the recommended preventive maintenance, inspection frequency and techniques, periodic adjustments, lubricants, and cleaning requirements. Furnish protective surfacing spare parts provided by the manufacturer.

PART 2 PRODUCTS

2.1 MATERIALS

Prior to the delivery of materials, submit certificates of compliance attesting that materials meet the specified requirements. Certified copies of the material certificates shall include composition and tests to which the material has been subjected. Submit manufacturer's descriptive data; catalogue cuts; and the latest edition of ASTM F1487 and CPSC Pub No 325. Provide materials which are the standard products of a manufacturer regularly engaged in the manufacture of protective surfacing and that are similar to surfacing in satisfactory use a minimum 5 year calendar period. Protective surfacing consists of two systems; synthetic surfacing and loose fill surfacing.

2.2 SYNTHETIC SURFACING

Submit a minimum 50 by 50 mm (2 by 2 inch) sample. Submit impact attenuation and critical height performance for each thickness of synthetic surfacing and loose fill surfacing provided. Submit delivery schedule and manufacturer's name for synthetic surfacing and loose fill surfacing plus delivery, storage and handling information. Furnish a list to include part numbers of furnished protective surfacing materials and components for synthetic surfacing and loose fill surfacing and manufacturer's specifications, handling and storage requirements, installation procedures, and safety data sheets to include warnings and critical height performance standards for synthetic surfacing and loose fill surfacing. Synthetic surfacing includes the following: poured-in-place system; tile system; and combination system. The synthetic surfacing consists of either impact attenuating substrate covered by a wear surface bonded to produce a unified system; a shredded rubber or aggregate substrate covered by a polyethylene plastic woven sheet wear surface; or a uniform material manufactured in such a way that the top portion meets the requirements specified for wear surface. Submit chemical composition, color granule percentage, and test results to which material has been subjected, identifying each material and component containing recycled materials and showing the estimated percentage of recovered material content. Furnish freezing temperature life-cycle durability.

2.2.1 Subbase

The subbase for synthetic surfacing may be concrete, aggregate, or bituminous material.

2.2.1.1 Concrete Subbase

Provide concrete material conforming to Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE.

2.2.1.2 Bituminous Subbase

Provide bituminous material conforming to Section 32 12 11 BITUMINOUS SURFACE TREATMENT.

2.2.1.3 Aggregate Subbase

Provide aggregate material conforming to Section 32 11 24 AGGREGATE AND/OR GRADED-CRUSHED AGGREGATE BASE COURSE.

2.2.2 Impact Attenuating Substrate

Provide a substrate compatible with the wear surface, and consisting of modular units; poured-in-place; or loose fill.

2.2.2.1 Poured-In-Place Substrate

Poured-in-place substrate shall consist of a 100 percent recycled, shredded, styrene butadiene rubber (SBR) adhered with a 100 percent solid polyurethane binder to form a resilient, porous material or shredded rubber. Strands of SBR may vary from a minimum 0.5 mm (1/50 inch) to a maximum 2 mm (2/25 inch) thickness; by a minimum 3 mm (1/8 inch) to a maximum 20 mm (4/5 inch) length. Binder shall be between a minimum 12 percent and a maximum 16 percent of the total weight of the mixture of rubber and urethane; and shall provide 100 percent coating of the particles. Foam rubber will not be accepted in the substrate.

2.2.2.2 Loose Fill Substrate

The loose fill substrate shall consist of 100 percent recycled shredded rubber produced from recycled vehicle tires without non-steel belts. Loose-fill strands may vary from a minimum 3 mm (1/8 inch) to a maximum 6 mm (1/4 inch) thickness; a minimum 3 mm (1/8 inch) to a maximum 13 mm (1/2 inch) width; and a minimum 13 mm (1/2 inch) to a maximum 50 mm (2 inch) length.

2.2.3 Wear Surface

Wear surfaces consist of the following: a poured-in-place durable, weather-resistant, ultraviolet stable, water permeable material top-coat; an integral component of a tile system; synthetic turf wear surface; rubber sheet wear surface; or a polyethylene woven plastic sheet wear surface. The wear surface shall meet requirements of ASTM D2047 for a minimum 0.8 coefficient of friction.

2.2.3.1 Poured-in-Place Wear Surface

Poured-in-place wear surface consists of ethylene propylene diene monomer (EPDM) particles adhered with a polyurethane binder formulated to produce an even, uniform surface. Particles of EPDM shall meet ASTM D412 for tensile strength and elongation, and contain a minimum 25 percent of rubber hydrocarbons. Particles of EPDM shall be peroxide or sulfur cured in accordance with the manufacturer. Size of rubber particles shall be between a minimum 1 mm (1/32 inch), and a maximum 3 mm (1/8 inch) diameter. Binder shall be between a minimum 16 percent and a maximum 21 percent total weight of rubber used in the wear surface, and shall provide 100 percent coating of the particles. Wear surface shall be a minimum 10 mm (3/8 inch) thick. The wear surface shall be porous.

2.2.3.2 Synthetic Turf Wear Surface

Synthetic turf wear surface shall consist of nylon fibers a minimum 500 denier, or heavy face weight polypropylene fiber a minimum 5,000 denier; and tufted construction conforming to ASTM F1015. Fibers in each roll shall be from the same dye lot.

2.2.3.3 Rubber Sheet Wear Surface

Rubber sheet wear surface shall consist of a smooth, uniform formulation of EPDM rubber granules bonded under pressure in the factory with polyurethane to form a continuous sheet, and shall be a minimum 10 mm (3/8 inch) thick. Up to a maximum 80 percent of the rubber may consist of SBR particles. Particle size shall vary from a minimum 1 mm (1/32 inch) to a maximum 5 mm (3/16 inch) diameter.

2.2.3.4 Polyethylene Plastic Woven Sheet Wear Surface

Polyethylene plastic woven sheet wear surface shall be lockstitched and meet the tear resistance test, ASTM D2261 or KS K 0536 and shall have an accelerated ultra-violet degradation protection feature.

2.2.4 Synthetic Tile

Synthetic tile shall be sized as indicated . Synthetic tile shall be a factory-molded unit consisting of the following: combining impact attenuating substrate and wear surface meeting requirements specified for substrate and wear surface; or a dual-density, uniform material, the top portion of which shall conform to wear surface requirements specified.

2.2.5 Color

Submit 2 color charts displaying surfacing colors, color granule percentages and finishes. The color shall be as indicated. An EPDM wear surface is preferred for color retention. Black or the following dark colored SBR wear surfaces retain heat and are not acceptable: color combinations containing more than 10 percent black; or color combinations averaging more than 10 percent dark colors.

2.2.6 Sealant

Sealant for tile or combined protective surface systems shall be compatible with the protective surfacing, and shall match the color of the wear surface.

2.2.7 Hardware

Hardware, anchors or fasteners shall be corrosion resistant stainless steel or galvanized steel to anchor the surfacing system securely, in accordance with manufacturer's instructions. Hardware shall provide or be recessed to provide a flat surface and shall be covered by the required depth of protective surfacing.

2.2.8 Binder

Binder for synthetic surfacing shall be nontoxic, weather-resistant, ultraviolet stable, non-hardening, and retaining impact-attenuating performance. It shall be 100 percent solids containing polyurethane, methylene diphenel isocyanate (MDI), or as recommended by the manufacturer. A maximum 2 percent of toluene diphenel isocyanate (TDI) shall be used. Weight of polyurethane shall be between a minimum 1.02 kg/L (8.5 lbs/gal) and a maximum 1.14 kg/L (9.5 lbs/gal). Coloring pigments shall be inorganic oxides.

2.2.9 Adhesive

Adhesive shall be a two component polyurethane providing extremely high impact resistant bond and shall be installed as recommended by the manufacturer. The adhesive shall be non-toxic, resistant to ultraviolet light, and safe for children. Adhesive shall conform to EPA registered uses, toxicity levels, and application hazards.

2.2.10 Containment Curbs

Containment curbs include the following: treated wood, concrete, recycled plastic, or recycled plastic molded as lumber. Containment curbs shall provide a smooth and hazard-free transition from the protective surfacing to the adjacent surface. Curbs shall be free of sharp vertical edges, protruding elements and trip hazards. Curbs shall be as recommended by the manufacturer. All edges should be provided with a minimum 13 mm (1/2 inch) radius.

2.2.11 Transition Edge

The transition edge shall be designed to maintain the protective surfacing performance, support the surfacing between changes of material, and shall be concrete in accordance with paragraph CONCRETE CURB. The face of the edge to the subgrade shall be covered with the impact attenuating surface and meet the requirements of paragraph CHILD SAFETY.

2.2.12 Combination System

Combination systems shall consist of combined protective surfacing materials specified. Each component is a part of a manufactured surfacing system. Wear surface shall be of the materials specified.

2.3 LOOSE-FILL SURFACING

Loose-fill surfacing installed in the use zone shall consist of sand, gravel or wood by-products.

2.3.1 Sand

Submit sieve test results. Sand shall be uniformly graded, washed, free of dust, clay, dirt, hazardous substances, or foreign objects. Sand particles shall be rounded naturally or by mechanical means and sieved in accordance with ASTM C136 or KS F 2502 to be in the following gradation range.

SIEVE SIZE	PERCENT PASSING
2.36 mm	100 percent
1.18 mm	80-100 percent
0.6 mm	40-75 percent
0.3 mm	0-25 percent
0.15 mm	less than 2 percent

SIEVE SIZE	PERCENT PASSING
#8	100 percent
#16	80-100 percent
#30	40 - 75 percent
#50	0-25 percent
#100	less than 2 percent

2.3.2 Gravel

Gravel shall be washed, free of dust, clay, dirt, hazardous substances or foreign objects. Gravel particles shall be rounded naturally or by mechanical means and sieved in accordance with ASTM C136 to be in the following gradation range.

SIEVE SIZE	PERCENT PASSING
12.5 mm	100 percent
9.5 mm	75-85 percent

SIEVE SIZE	PERCENT PASSING
1/2 inch	100 percent
3/8 inch	75-85 percent

2.3.3 Wood By-Products

Wood by-products include wood mulch and engineered wood fiber. Wood by-products shall be free of sharp or foreign objects or toxic chemicals; poisonous plant material; protrusions; or hazardous material; provide information regarding composition, source, and particle size. Wood by-products manufactured from recycled pallets or lumber containing nails or metal fasteners shall be rejected.

2.3.3.1 Wood Mulch

Wood mulch shall be untreated chipped bark and/or untreated chipped tree prunings a maximum 40 mm (1-1/2 inches) long and shall be free of twigs, leaves, branches, thorns, dirt, grass, yard clippings, soil, or poisonous plants.

2.3.3.2 Engineered Wood Fiber

Engineered wood fiber manufactured for the purpose of protective surfacing shall consist of particles varying from a minimum 3 mm (1/8 inch) wide to a maximum 13 mm (1/2 inch) thick; and a minimum 25 mm (1 inch) wide to a maximum 75 mm (3 inches) long.

2.4 GEOTEXTILE FABRIC

Geotextile fabric consists of the following: nonwoven polypropylene sheet; nonwoven 100 percent polyester sheet; or nonwoven needle punched polyester sheet composed of recycled polyester resins.

2.5 RECYCLED PLASTIC

Provide the estimated percentage of recovered material content in the material and components; and life-cycle durability. Submit individual component and assembled unit structural integrity test; creep tolerance; deflection tolerance; and vertical load test results. The estimated percentage of recovered material content in the material and components. Life-cycle durability.

2.5.1 High Density Polyethylene

The material shall be molded of ultraviolet (UV) and color stabilized polyethylene; and consist of a minimum 75% plastic profile of high-density polyethylene, low-density polyethylene, and polypropylene raw material. The material shall be non-toxic and have no discernible contaminates such as paper, foil, or wood. The material shall contain a maximum 3 percent air voids. The material shall be free of splinters, chips, peels, buckling, and cracks. Material shall be resistant to deformation from solar heat gain. Material shall have factory-drilled holes. Components with extra holes not filled by hardware or covered by other components shall be rejected. The material shall not be painted.

2.5.2 Structural Component

Recycled plastic materials will not be used as load bearing structural members.

2.5.3 Recycled Plastic Molded As Lumber

The component shall deflect a maximum 1/360 of the span of the frame when exposed to a uniform live load of 585 N/m (40 lbs/ft), ASTM D648. The product shall meet the structural integrity test requirements set forth in ASTM F1487 and ASTM D6112.

2.6 CURBS

2.6.1 Concrete Curb

Concrete curbs shall conform to Section 32 16 13 CONCRETE SIDEWALKS AND CURBS AND GUTTERS

2.6.2 Wood

2.6.2.1 Wood Components

Wood components shall be exterior premium grade and free of knots. Identify wood components obtained from managed forests. Wood components shall have factory-drilled holes. Components with extra holes not filled by hardware or covered by other components shall be rejected.

2.6.2.2 Wood Treatment

Wood components that are not naturally rot and insect resistant shall be treated to resist rot and insect attack by using standard treatment procedures. Provide wood treatment chemical content, toxicity level, and life-cycle durability. Any wood placed up to a maximum 150 mm (6 inches) above, or any portion below the top elevation of the protective surfacing, shall be treated after fabrication. Creosote, pentachlorophenol, and tributyl tin oxide are prohibited according to ASTM F1487.

PART 3 EXECUTION

3.1 SITE PREPARATION

Prior to installing the protective surfacing, verify the playground equipment and site furnishings are installed in accordance with Section 11 68 13 PLAYGROUND EQUIPMENT.

3.1.1 Finished Grade and Underground Utilities

Submit finished grade, underground utilities, storm-drainage system and irrigation system status; and location of underground utilities and facilities. Verify that finished grades are as indicated; the smooth grading has been completed in accordance with Section 31 00 00 EARTHWORK; installation of the underground utilities through the area has been completed in accordance with Section 31 00 00 EARTHWORK; installation of the storm-drainage system through the area has been completed in accordance with Section 33 40 00 STORM DRAINAGE; and the installation of underground sprinklers through the area has been completed in accordance with Section 32 84 24 UNDERGROUND SPRINKLER SYSTEMS. The location of underground utilities and facilities in the area of the operation shall be verified. Damage to underground utilities and facilities shall be repaired at the Contractor's expense.

3.1.2 Layout

The layout of the entire use zone perimeter shall be staked before excavation begins. The location of all elements shall be staked to include the following: All play event configuration access and egress points; and use zone perimeters. The use zone is defined as the area beneath and immediately adjacent to a play structure or equipment that is designated for unrestricted circulation around equipment; and on whose surface it is predicted that a user would land when falling from or exiting the equipment. Also, the use zone is associated with the following terms; "Clear Area," and "Fall Zone". The use zone shall be free of hard surfaces, objects or obstacles that a child could run into or fall on top of and be injured. Use zone perimeters shall not overlap hard surfaces. The use zone perimeter shall meet or exceed the requirements of paragraphs CHILD SAFETY and CHILD ACCESSIBILITY. Use zone perimeters shall not overlap except for certain play events as defined in ASTM F1487.

3.1.3 Obstructions Below Ground

When obstructions below ground affect the work, shop drawings showing proposed adjustments shall be provided.

3.1.4 Percolation Test

Submit a certified report of inspection, test method used and compliance with recognized test standard shall be described. A test for percolation shall be done to determine positive drainage, to include the lowest elevation of the subgrade in the areas containing the following: sand; gravel; wood by-products; or synthetic surfacing installed over a pervious base. A positive percolation shall consist of a minimum 25 mm (1 inch) per 3 hour period. When a negative percolation test occurs, a shop drawing shall be provided to indicate the corrective measures.

3.1.5 Substitution

Under no circumstances are substitutions to be allowed or protective surfacing to be selected without written approval from the technical representative. Evaluate manufacturer substitutions for the critical height value with meeting the site conditions and paragraph FALL HEIGHT.

3.1.6 Subgrade

Correct subgrade irregularities to ensure the required depth of protective surfacing is provided. The subgrade elevation shall be as required by the manufacturer.

3.1.7 Subsurface

Install the subsurface in a true, even plane, and sloped to provide positive drainage as indicated.

3.1.8 Subbase

Tolerance of the concrete or bituminous subbase shall be within a maximum 6 mm in 3 m (1/4 inch in 10 feet). Tolerance of aggregate subbase shall be within a maximum similar to 6 mm in 3 m (1/4 inch in 10 feet). Compact aggregate subbase to a maximum 95 percent, ASTM D1557 or KS F 2312. The compaction shall be completed in accordance with Section 31 00 00 EARTHWORK. Sand, gravel, and wood products shall not be installed over a concrete, aggregate, or bituminous subbase, in accordance with paragraph CHILD SAFETY.

3.1.9 Concrete or Bituminous Curing

Bituminous or concrete subbase shall be cured in accordance with the manufacturer's requirements. Curing compounds and other deleterious substances that adversely affect adhesion shall be removed. Surface shall be clean and dry.

3.1.10 Fall Height

3.1.10.1 General Requirements

The fall height is defined as the vertical distance between the finished elevation of the designated play surface and the finished elevation of the protective surfacing beneath it. For some play events the fall height and platform height are the same, while for other play events the fall height and maximum equipment height are the same, Section 11 68 13 PLAYGROUND EQUIPMENT. When the furnished play event fall height varies from the play event shown, shop drawings shall be provided defining the revised depth or type of protective surfacing to meet or exceed the requirements of paragraphs CHILD SAFETY and CHILD ACCESSIBILITY.

3.1.10.2 Measuring Fall Height

EQUIPMENT	MEASURING FALL HEIGHT
Composite Equipment Structure:	For a platform surrounded by protective barriers, measure from the platform finished elevation.
	For a platform surrounded by guardrails, measure from the guardrail top elevation.
Infant Crawl Area:	A maximum 600 mm (24 inches) height, measured from the crawl wall or barrier finished elevation.
Playhouse, Nonclimbable:	Measure from the designated play surface finished elevation.
Spring Rocking Equipment:	Measure from the seat top elevation.
Stationary Equipment, Climbable:	Measure from the maximum equipment height finished elevation.

EQUIPMENT	MEASURING FALL HEIGHT
Stationary Equipment, Nonclimbable:	Measure from the designated play surface finished elevation.
Swing:	Measure from the bottom of the pivot point.

3.2 INSTALLING SYNTHETIC SURFACING SYSTEM

Surfacing edges shall fully adhere to the subsurface. Fully cover the subsurface to ensure no hard surfaces are exposed through displacement of loose fill. Rolled or beveled containment curb or transition edges shall maintain the full thickness required to meet paragraphs CHILD SAFETY and CHILD ACCESSIBILITY. Material shall cover foundation and cutouts around elements penetrating the surface. Seams shall be the minimum necessary and shall be tight.

3.2.1 Temperature Limitation

Provide temperature limitations for applying adhesive.

3.2.2 Poured-in-Place System

Components of the poured-in-place system shall be mixed mechanically on site in accordance with manufacturer's recommendations. Hand-mixing is prohibited. Installation of poured-in-place surfacing shall be seamless and completely bonded to subsurface. Material shall cover foundations and shall be tight around elements penetrating the surface. Add a minimum 2 mm (1/16 inch) depth to the required surfacing depth to ensure the full depth of material is installed to meet paragraph CHILD SAFETY.

3.2.2.1 Geotextile Fabric for Poured-In-Place

Install geotextile fabric over a compacted aggregate base as indicated. Fabric shall cover the entire area and shall be lapped a minimum 100 mm (4 inch) width at the seams. Seams shall be adhered in accordance with manufacturer's recommendations. The aggregate base shall be free of ruts or protruding objects. The fabric shall be installed smooth; and free of tensile stresses, folds, and wrinkles. The fabric shall be protected from clogging, tears, or other damage. Damaged fabric shall be repaired or replaced as directed.

3.2.2.2 Poured-in-Place Substrate

The substrate layer of the poured-in-place system shall be installed in one continuous pour on the same day. When a second pour is required, the edge of the previous work shall be fully coated with polyurethane binder to ensure 100 percent bond with new work. Adhesive shall be applied in small quantities so that new substrate can be placed before the adhesive dries.

3.2.2.3 Poured-in-Place Wear Surface

Wear surface shall be bonded to substrate. Adhesive shall be applied to substrate in small quantities so that wear surface can be applied before adhesive dries. Surface shall be hand troweled to a smooth, even finish. When wear surface is composed of different color patterns, pour shall be continuous and seamless. When seams are required due to color change or field conditions, the adjacent wear surface shall be placed as soon as possible, before initial pour has cured. The edge of initial pour shall be coated with adhesive and wear surface mixture shall be immediately applied.

3.2.3 Tile System

Tile shall be laid out to ensure that end cuts are equal. Tile shall be installed in accordance with manufacturer's instructions. Hardware shall be as recommended by the manufacturer. Tile shall be bonded to the subsurface with an adhesive approved by the manufacturer. Cutouts shall be filled with sealant according to manufacturer's instructions to eliminate voids at equipment. Sealant shall be the minimum amount necessary, shall not exceed a maximum 10 mm (3/8 inch) width. Where excessive voids occur at cutouts, tile shall be removed and refitted. The tile system shall be installed throughout the play equipment use zone with the proper thickness.

3.2.4 Combination System

The combination system shall consist of modular impact attenuating substrate units, adhered to form a unified systemor shredded rubber tires over a gravel substrate. The substrate shall be covered with a wear surface as specified. Cutouts around equipment shall be properly filled and sealed according to manufacturer's instructions to eliminate voids. Sealant shall be the minimum amount necessary, shall not exceed a maximum 10 mm (3/8 inch) width. Where excessive voids occur at cutouts, the modular substrate shall be removed and refitted. Construction methods shall be employed to ensure full depth installation of specified surfacing material and the finished wear surface.

3.2.4.1 Geotextile Fabric

Geotextile fabric shall be installed where a modular or shredded rubber substrate is installed over an aggregate base. It should be installed with poured-in-place wear surface or polyethylene plastic woven sheet wear surface installed over substrate. Fabric shall cover the entire area to receive the tile system and shall be lapped a minimum 100 mm (4 inch) width at the seams. Seams shall be adhered in accordance with manufacturer's recommendations.

3.2.4.2 Modular Substrate

Modular substrate shall be laid out to minimize small end pieces. The substrate shall be installed in accordance with manufacturer's instructions.

3.2.4.3 Poured-in-Place Substrate

Same as paragraph POURED-IN-PLACE SYSTEM.

3.2.4.4 Synthetic Turf Wear Surface

Wear surface shall be bonded to substrate with 100 percent solids polyurethane adhesive. Surface irregularities and wrinkles shall be corrected. Seams shall be secured in accordance with manufacturer's recommendations. Wear surface roll width shall be as wide as practical for the installation.

3.2.4.5 Rubber Sheet Wear Surface

Wear surface shall be bonded to substrate with 100 percent solids polyurethane adhesive. Surface irregularities and wrinkles shall be corrected. Seams shall be secured in accordance with manufacturer's recommendations. Wear surface roll width shall be as wide as practical for the installation.

3.2.4.6 Poured-in-Place Wear Surface

Same as paragraph POURED-IN-PLACE SYSTEM.

3.2.4.7 Polyethylene Plastic Woven Sheet Wear Surface

Wear surface shall be securely anchored to a perimeter containment material with hardware in accordance with the manufacturer's instructions. Hardware shall be appropriate for the type of system and secured to eliminate protrusions.

3.3 LOOSE FILL SURFACING SYSTEM

Submit a minimum 0.003 cu. m (0.125 cu. ft) sample.

3.3.1 Sand Surfacing System

Sand shall be installed over a compacted subgrade at a minimum 450 mm (18 inches) depth throughout the use zone. The finished elevation of sand shall be determined after sand has been settled by saturating with water and percolating. The sand depth in high play activity areas shall be as indicated. Sand shall meet the requirements of paragraph CHILD SAFETY.

3.3.2 Gravel Surfacing System

Gravel shall be installed over a compacted subgrade at a minimum 300 mm (12 inch) depth throughout the use zone. The depth of gravel in high play activity areas shall be as indicated. Gravel shall meet the requirements of paragraph CHILD SAFETY.

3.3.3 Wood By-Product Surfacing System

Engineered wood fiber protective surfacing shall be installed according to manufacturer's instructions. Wood products shall meet the requirements of paragraph CHILD SAFETY.

3.3.3.1 Wood Mulch Surfacing System

Wood mulch shall be installed over a compacted subgrade covered with geotextile fabric. Wood mulch shall meet the requirements of paragraph CHILD SAFETY

3.3.3.2 Engineered Wood Fiber Surfacing System

Engineered wood fiber protective surfacing shall be installed according to manufacturer's instructions. The surfacing shall meet the requirements of paragraphs CHILD SAFETY and CHILD ACCESSIBILITY.

3.3.3.3 Geotextile Fabric for Wood By-Product

Geotextile fabric shall cover the entire area and shall be lapped a minimum 100 mm (4 inch) width at the seams. Seams shall be adhered in accordance with manufacturer's recommendations. Folds, wrinkles, or loose fabric shall be smoothed. Fabric shall be protected from damage during wood product placement.

3.3.3.4 Minimum Depth for Wood By-Product

Wood by-product shall be installed at a minimum 300 mm (12 inch) depth throughout the use zone. The depth of wood products in high play activity areas shall be as indicated.

3.4 RESTORATION AND CLEAN UP

When the operation has been completed, clean up and protect the site. Existing areas that have been damaged from the operation shall be restored to original condition at the Contractor's expense.

3.4.1 Clean Up

The site and play events shall be cleaned of all materials associated with the operation. Play events and surfaces shall be cleaned of dirt, stains, filings, and other blemishes occurring from shipment and installation. Cleaning methods and agents shall be as recommended by the manufacturer.

3.4.2 Protection

The area shall be protected as required or directed by providing barricades and signage. Signage shall be in accordance with Section 10 14 01 EXTERIOR SIGNAGE

3.4.3 Disposal of Materials

Excess and waste material shall be removed and disposed of off Government property.

3.5 PROTECTIVE SURFACING ACCEPTANCE

Submit record of measurements and findings by the certified playground safety inspector. When the protective surfacing is installed, the play events and protective surfacing shall be thoroughly inspected and measured to verify the playground meets manufacturer's recommendations, paragraphs CHILD SAFETY and CHILD ACCESSIBILITY, and paragraph FALL HEIGHT as follows: 1) secure anchoring; 2) all hardware and connectors are tight and below the wear surface; 3) sharp points, edges, and protrusions; 4) entanglement; and 5) pinch, crush, and shear points.

a. Measure use zone distances to determine the area is free of hard surfaces, objects or obstacles. Determine exceptions to use zone overlaps occur in accordance with ASTM F1487. Measure play event fall height and compare to critical height value for the thickness of installed synthetic surfacing. Measure play event fall height and depth of loose fill protective surfacing.

b. Ensure installed chopped tire material is free from steel belts. Ensure the slide exit region has the required clear zone. Swing seat clearances are measured while occupied by a maximum user for the age group using the equipment.

c. The finished installation shall have the appearance of a single covering. Protective surfacing that does not comply shall be reinstalled. Hardware that does not comply shall be replaced. Ensure positive drainage for the area and the lowest elevation of protective surfacing subgrade has been provided.

d. A written report describing the results of the evaluation shall be provided.

3.6 RE-INSTALLATION

When re-installation is required, the following shall be accomplished. Re-install the product as specified. Provide new replacement materials supplied by the manufacturer (material acquisition of replacement parts is the responsibility of the Contractor). Damage caused by the failed installation shall be repaired at the Contractor's expense.

-- End of Section --

SECTION 32 31 13.53

HIGH-SECURITY CHAIN LINK FENCES AND GATES
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A121	(2007) Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A176	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip
ASTM A392	(2011a) Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A478	(1997; R 2008) Standard Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire
ASTM A666	(2010) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM A702	(1989; R 2006) Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R 2007) Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM F1043	(2011a) Strength and Protective Coatings on Metal Industrial Chain-Link Fence Framework
ASTM F1083	(2010) Standard Specification for Pipe,

	Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM F1184	(2005; R 2010) Industrial and Commercial Horizontal Slide Gates
ASTM F567	(2011a) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2008) Standard Specification for Fence Fittings
ASTM F668	(2011) Poly(Vinyl Chloride) (PVC) and other Organic Polymer-Coated Steel Chain-Link Fence Fabric
ASTM F883	(2009) Padlocks
ASTM F900	(2011) Industrial and Commercial Swing Gates

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping
KS D 3703	(2007) Stainless Steel Wires
KS D 7011	(2002) Zinc-coated low carbon steel wires
KS D 7037	(2000) Aluminum-coated steel wire
KS D 8308	(2001) Zinc Hot Dip Galvanizings
KS F 4009	(2011) Ready-Mixed Concrete

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

- Fence Installation
- Installation Drawings
- Location of gate, corner, end, and pull posts
- Gate Assembly
- Turnstiles
- Gate Hardware and Accessories

SD-03 Product Data

- Fence Installation
- Gate Assembly
- Gate Hardware and Accessories
- Concrete

FENCE FABRIC
Posts
Post Caps
Braces
Line Posts
Sleeves
Tension Wire
Barbed Wire
Barbed Wire Supporting Arms
Barbed Tape
Stretcher Bars
Gate Posts
Gate Hardware and Accessories
Turnstiles
Padlocks
Wire Ties
ELECTRO-MECHANICAL LOCKS
GATE OPERATOR

SD-07 Certificates

Reports

SD-08 Manufacturer's Instructions

Fence Installation
Gate Assembly
Hardware Assembly

SD-10 Operation and Maintenance Data

Operating and maintenance instructions

1.3 QUALITY ASSURANCE

1.3.1 Required Report Data

Submit reports, signed by an official authorized to certify on behalf of the manufacturer, of chain-link fencing listing and accessories regarding weight in grams (ounces) for zinc coating, thickness of PVC coating, and chemical composition and thickness of aluminum alloy coating.

1.3.2 Assembly and Installation Drawings

Submit Manufacturer's instructions and complete Fence Installation Drawings for review and approval by the Contracting Officer prior to shipment. Drawing details shall include, but are not limited to: Fence Installation, Location of gate, corner, end, and pull posts, Gate Assembly, Turnstiles, and Gate Hardware and Accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 FENCE FABRIC

2.1.1 General

Provide ASTM A392, Class 1 Class 2, or KS D 7011 zinc-coated steel wire with minimum coating weight of 370 grams (1.2 ounces) of zinc per square meter (foot) of coated surface, or Class 2b polyvinyl chloride-coated steel fabric with 92 grams (0.3 ounces) of zinc coating per square meter (foot) in accordance with ASTM F668 as indicated in contract drawings. Polyvinyl chloride coating for fabric and all other fence components shall be manufacturer's standard color. Set fabric height as shown in contract drawings. Fabric shall be twisted and barbed on the top selvage and knuckled on the bottom selvage. Secure fabric to posts using stretcher bars or ties spaced 375 mm (15 inches) on center, or by integrally weaving to integral fastening loops of end, corner, pull, and gate posts for full length of each post. Install fabric on opposite side of posts from area being secured.

2.1.2 Approval Of Polyvinyl Chloride-Coated Fence Materials

The Contracting Officer will thoroughly inspect polyvinyl chloride-coated fence materials for cracking, peeling, and conformance with the specifications prior to installation. Any fence materials rejected by the Contracting Officer shall be replaced by the Contractor with approved materials at no additional cost to the Government.

2.2 POSTS

2.2.1 Metal Posts for Chain Link Fence

Provide posts conforming to ASTM F1083 or KS D 3507, zinc-coated. Group IA, with external coating Type A steel pipe. Group IC steel pipe, zinc-coated with external coating Type A or Type B and Group II , roll-formed steel sections, meeting the strength and coating requirements of ASTM F1043 and ASTM A702. Group III, ASTM F1043 steel H-section may be used for line posts in lieu of line post shapes specified for the other classes. Post shall be either Group IA steel pipe, Group IC, Group II, roll-formed steel sections, or Group III steel H-sections and be zinc coated (Type A) and polyvinyl chloride coated conforming to the requirements of ASTM F1043. Provide sizes as shown on the drawings. Line posts and terminal (corner, gate, and pull) posts selected shall be of the same designation throughout the fence. Provide gate post for the gate type specified subject to the limitation specified in ASTM F900 and/or ASTM F1184. Post spacing shall conform to the recommended guidelines as set forth in the CLFMI "Wind Load Guide for the Selection of Line Post Spacing and Size" unless specified to exceed those guidelines.

2.2.2 Accessories

a. Provide accessories conforming to ASTM F626. Ferrous accessories shall be zinc or aluminum coated. also be polyvinyl chloride-coated, minimum thickness of 0.152 mm (0.006 inch), maximum thickness of 0.381 mm (0.015 inch). Match color coating of fittings to color coating of the fabric.

b. Furnish truss rods for each terminal post. Provide truss rods with turnbuckles or other equivalent provisions for adjustment.

c. Provide Barbed wire supporting arms of the V 6 strand arm type and of the design required for the post furnished. Secure arms by top tension wire, unless otherwise indicated on contract drawings.

d. Furnish post caps in accordance with manufacturer's standard accessories.

e. Provide 9 gauge steel tie wire for attaching fabric to rails, braces, and posts and match the coating of the fence fabric. Tie wires for attaching fabric to tension wire on high security fences shall be 1.6 mm (16 gage) stainless steel. Provide double loop tie wires 165 mm (6.5 inches) in length. Miscellaneous hardware coatings shall conform to ASTM A153/A153M or KS D 8308 unless modified.

2.3 BRACES AND RAILS

ASTM F1083, zinc-coated, Group IA, steel pipe, size NPS 1-1/4 or KS D 3507, zinc-coated. Group IC steel pipe, zinc-coated, shall meet the strength and coating requirements of ASTM F1043. Braces and rails shall be Group IA or Group IC, steel pipe, size NPS 1-1/4 or Group II, formed steel sections, size 42 mm (1-21/32 inch) and be zinc coated (Type A) and polyvinyl chloride-coated conforming to the requirements of ASTM F1043. Group II, formed steel sections, size 42 mm (1-21/32 inch), conforming to ASTM F1043, may be used as braces and rails if Group II line posts are furnished.

2.4 WIRE

2.4.1 Wire Ties

Submit samples as specified. Provide wire ties constructed of the same material as the fencing fabric. Provide accessories with polyvinyl (PVC) coatings similar to that specified for chain-link fabric or framework.

2.4.2 Barbed Wire

Provide barbed wire conforming to ASTM A121 zinc-coated, Type Z, Class 3, or aluminum-coated, Type A, with 12.5 gauge wire with 14 gauge, round, 4-point barbs spaced no more than 125 mm (5 inches) apart.

2.4.3 Tension Wire

Provide Type I or Type II tension wire, Class 4 coating, in accordance with ASTM A824 or KS D 7037, SWMA-A or KS D 7011 SWMGS-7.

2.5 BARBED TAPE

Provide reinforced barbed tape, double coil or single coil, as indicated, for fence toppings fabricated from 430 series stainless steel with a hardness range of Rockwell (30N) 37-45 conforming to the requirements of ASTM A176. Provide stainless steel strip 0.6 mm thick by 25 mm (0.025 inch thick by 1 inch) wide before fabrication. Each barb shall be a minimum of 30.5 mm (1.2 inch) in length, in groups of 4, spaced on 102 mm (4 inch) centers. The stainless steel core wire shall have a 2.5 mm (0.098 inch) diameter with a minimum tensile strength of 9.68 MPa (140 psi) and be in accordance with ASTM A478 or KS D 3703, Type STS304-W2, STS305-W2 or STS317-W2. Reinforced barbed tape, single coil, for ground application shall meet the above requirements. Non-reinforced barbed tape, single coil, for ground applications shall be fabricated from 301 series stainless steel, with a hardness range of Rockwell (30N) 50-55, in accordance with ASTM A666. The stainless steel strip shall be 0.6 mm thick by 31 mm (0.025 inch thick by 1.21 inches) wide before fabrication. Each barb shall be a minimum of 30.5 mm (1.2 inch) in length, in groups of 4, spaced on 102 mm (4 inch) centers. Use sixteen gauge stainless steel twistable wire ties for attaching the barbed tape to the barbed wire and to the fence for ground application.

2.6 CONCRETE

ASTM C94/C94M or KS F 4009, using 19 mm (3/4 inch) maximum size aggregate, and having minimum compressive strength of 21 MPa (3000 psi) at 28 days. Grout shall consist of one part portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix.

2.7 GATES

2.7.1 Gate Assembly

Provide gate assembly conforming to ASTM F900 and/or ASTM F1184 of the type and swing shown. Provide gate frames conforming to strength and coating requirements of ASTM F1083 for Group IA, steel pipe, with external coating Type A, nominal pipe size (NPS) 1-1/2 or KS D 3507. Provide gate frames conforming to strength and coating requirements of ASTM F1043, for Group IC, steel pipe with external coating Type A or Type B, nominal pipe size (NPS) 1-1/2. Gate fabric shall be as specified for chain link fabric.

2.7.2 Gate Leaves

For gate leaves, more than 2.44 m (8 feet) wide, provide either intermediate members and diagonal truss rods or tubular members as necessary to provide rigid construction, free from sag or twist. Gate leaves less than 2.44 m (8 feet) wide shall have truss rods or intermediate braces. Provide intermediate braces on all gate frames with an electro-mechanical lock. Attach fabric to the gate frame by method standard with the manufacturer except that welding will not be permitted.

2.7.3 Gate Hardware and Accessories

Submit manufacturer's catalog data. Furnish and install latches, hinges, stops, keepers, rollers, and other hardware items as required for the operation of the gate. Arrange latches for padlocking so that the padlock will be accessible from both sides of the gate. Provide stops for holding the gates in the open position. For high security applications, each end member of gate frames shall be extended sufficiently above the top member to carry three strands of barbed wire in horizontal alignment with barbed wire strands on the fence.

2.8 Turnstiles

Provide galvanized steel , three wing turnstile consisting of a rotor, cage, ceiling plate, and bottom bearing plate. Provide continuous turn motion, unless otherwise indicated in contract drawings.

2.9 PADLOCKS

Provide padlocks conforming to ASTM F883, Type PO1, Options A, B, and G and Grade 6. Size 44 mm (1-3/4 inch). Key all padlocks into master key system as specified in Section 08 71 00 DOOR HARDWARE.

2.10 GATE OPERATOR

Provide electric gate operators for sliding gates as follows: Electrical gate operators shall have a right angle gear-head instantly reversing motor with magnetic drum-type brake, friction disc clutch, reversing starter with thermal overload protection, and a chain-driven geared rotary-type automatic limit switch. Gears shall consist of a hardened steel machine cut worm and mating bronze gear. All gears and bearings shall operate in a bath of oil. Gate operators with V-belt pulleys are not allowed. Equip gate operators with an emergency release to allow the gate to be operated manually. The emergency release mechanism shall be capable of being locked in the engaged or disengaged position. Provide positive stops on the gate tracks as a backup to the limit switches.

2.11 ELECTRO-MECHANICAL LOCKS

Electro-mechanical locking devices for sliding gates and personnel gates shall be solenoid actuated such that the deadbolt retracts when the solenoid is energized and remains electrically retracted until the gate is closed. Provide continuous duty type solenoid, rated for 120V ac, 60Hz operation. The locking device shall be unlockable by key and keyed on both sides. Status of the electro-mechanical lock shall be monitored by two limit switches (integral to the locking device) wired in series. One switch shall monitor the deadlock lever and the other monitor the locking tongue.

PART 3 EXECUTION

3.1 FENCE INSTALLATION

Perform complete installation conforming to ASTM F567.

3.1.1 Line and Grade

Install fence to the lines and grades indicated. Clear the area on either side of the fence line to the extent indicated. Space line posts equidistant at intervals not exceeding 3 m (10 feet). Terminal (corner, gate, and pull) posts shall be set at abrupt changes in vertical and horizontal alignment. Provide fabric continuous between terminal posts; however, runs between terminal posts shall not exceed 152.4 m (500 feet). Repair any damage to galvanized surfaces, including welding, with paint containing zinc dust in accordance with ASTM A780/A780M.

3.1.2 Excavation

Clear all post holes of loose material. Spread waste material where directed. Eliminate ground surface irregularities along the fence line to the extent necessary to maintain a 25 mm (1 inch) clearance between the bottom of the fabric and finish grade, unless otherwise indicated on contract drawings.

3.1.3 Concrete Slabs and Walls

Set posts into zinc-coated sleeves, set in concrete slab or wall, to a minimum depth of 300 mm (12 inches). Fill sleeve joint with lead, nonshrink grout, or other approved material. Set posts for support of removable fence sections into sleeves that provide a tight sliding joint and hold posts aligned and plumb without use of lead or setting material.

3.2 POST INSTALLATION

3.2.1 Earth and Bedrock

a. Set posts plumb and in alignment. Except where solid rock is encountered, set posts in concrete to the depth indicated on the drawings. Where solid rock is encountered with no overburden, set posts to a minimum depth of 457 mm (18 inches) in rock. Where solid rock is covered with an overburden of soil or loose rock, set posts to the minimum depth indicated on the drawing unless a penetration of 457 mm (18 inches) in solid rock is achieved before reaching the indicated depth, in which case terminate depth of penetration. Grout all portions of posts set in rock.

b. Portions of posts not set in rock shall be set in concrete from the rock to ground level. Posts set in concrete shall be set in holes not less than the diameter shown on the drawings. Make diameters of holes in solid rock at least 25 mm (1 inch) greater than the largest cross section of the post. Thoroughly consolidate concrete and grout around each post, free of voids and finished to form a dome. Allow concrete and grout to cure for 72 hours prior to attachment of any item to the posts. Group II line posts may be mechanically driven, for temporary fence construction only, if rock is not encountered. Set driven posts to a minimum depth of 914 mm (3 feet) and protect with drive caps when setting.

c. Test fence post rigidity by applying a 222.4 newtons (50 pound) force on the post, perpendicular to the fabric, at 1.52 m (5 feet) above ground. Post movement measured at the point where the force is applied shall be less than or equal to 19 mm (3/4 inch) from the relaxed position. Test every tenth post for rigidity. When a post fails this test, make further tests on the next four posts on either side of the failed post. All failed posts shall be removed, replaced, and retested at the Contractor's expense.

3.2.2 Concrete Slabs and Walls

Set posts into zinc-coated sleeves, set in concrete slab or wall, to a minimum depth of 300 mm (12 inches). Fill sleeve joint with lead, nonshrink grout, or other approved material. Set posts for support of removable fence sections into sleeves that provide a tight sliding joint and hold posts aligned and plumb without use of lead or setting material.

3.3 RAILS

Bolt bottom rail to double rail ends and securely fasten double rail ends to the posts. Peen bolts to prevent easy removal. Install bottom rail before chain link fabric.

3.4 FABRIC INSTALLATION

a. Install chain link fabric on the side of the post indicated. Attach fabric to terminal posts with stretcher bars and tension bands. Space bands at approximately 381 mm (15 inch) intervals. Install fabric and pull taut to provide a smooth and uniform appearance free from sag, without permanently distorting the fabric diamond or reducing the fabric height. Fasten fabric to line posts at approximately 381 mm (15 inch) intervals and fastened to all rails and tension wires at approximately 610 mm (24 inch) intervals, unless otherwise indicated on contract drawings.

b. Cut fabric by untwisting and removing pickets. Accomplish splicing by weaving a single picket into the ends of the rolls to be joined. The bottom of the installed fabric shall be 50 mm plus or minus 13 mm (2 plus or minus 1/2 inch) above the ground.

c. After the fabric installation is complete, exercise the fabric by applying a 222 newtons (50 pound) push-pull force at the center of the fabric between posts; the use of a 133 newtons (30 pound) pull at the center of the panel shall cause fabric deflection of not more than 63.5 mm (2.5 inches) when pulling fabric from the post side of the fence; every second fence panel shall meet this requirement; resecure and retest all failed panels at the Contractor's expense.

3.5 SUPPORTING ARMS

Install barbed wire supporting arms and barbed wire as indicated on the drawings and as recommended by the manufacturer. Anchor supporting arms to the posts in a manner to prevent easy removal with hand tools with 9.5 mm (3/8 inch) diameter plain pin rivets or, at the Contractor's option, with studs driven by low-velocity explosive-actuated tools for steel, wrought iron, ductile iron, or malleable iron. Studs driven by an explosive-actuated tool shall not be used with gray iron or other material that can be fractured. Use a minimum of two studs per support arm. Pull barbed wire taut and attach to the arms with clips or other means that will prevent easy removal.

3.6 BARBED TAPE INSTALLATION

Install stainless steel reinforced barbed tape as detailed on the drawings. Stretch out barbed tape to its manufacturer's recommended length, set on top of the barbed wire and "V" shaped support arms, then secure it to the barbed wire. Secure the barbed tape to the barbed wire at the two points and at every spiral turn of both coils as shown on the drawings. Install stainless steel reinforced barbed tape for ground applications in accordance with manufacturer's recommendations.

3.7 GATE INSTALLATION

a. Install gates at the locations shown. Mount gates to swing as indicated. Install latches, stops, and keepers as required. Install Slideor Lift gates as recommended by the manufacturer.

b. Attach padlocks to gates or gate posts with chains. Weld or otherwise secure hinge pins, and hardware assembly to prevent removal.

c. Submit one hard copy & one digital copy (.pdf - text searchable) of operating and maintenance instructions, a minimum of 2 weeks prior to field training. Operating instructions shall outline the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Include in the maintenance instructions routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. Also include the general gate layout, equipment layout and simplified wiring and control diagrams of the system as installed.

3.8 GROUNDING

a. Ground fencing as indicated on drawings.

b. Ground fences crossed by overhead power lines in excess of 600 volts. Electrical equipment attached to the fence shall be grounded.

c. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within 15 m (50 feet) of the fence, and where the fence alignment changes more than 15 degrees. Grounding locations shall not exceed 198 m (650 feet). Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by power lines of 600 volts or more at or near the point of crossing and at distances not exceeding 45 m (150 feet) on each side of crossing.

d. Provide ground conductor consisting of No. 8 AWG solid copper wire. Grounding electrodes shall be 19 mm (3/4 inch) by 3.05 m (10 foot) long copper-clad steel rod. Drive electrodes into the earth so that the top of the electrode is at least 152 mm (6 inches) below the grade. Where driving is impracticable, electrodes shall be buried a minimum of 305 mm (12 inches) deep and radially from the fence. The top of the electrode shall not be less than 610 mm (2 feet) or more than 2.4 m (8 feet) from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Total resistance of the fence to ground shall not be greater than 25 ohms.

3.9 SECURITY

Install new security fencing, remove existing security fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer and cognizant Security Officer.

3.10 CLEANUP

Remove waste fencing materials and other debris from the work site each workday.

-- End of Section --

SECTION 32 31 13

CHAIN LINK FENCES AND GATES
08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A116	(2011) Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A702	(1989; R 2006) Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A90/A90M	(2011) Standard Test Method for Weight Mass of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM F1043	(2011a) Strength and Protective Coatings on Metal Industrial Chain-Link Fence Framework
ASTM F1083	(2010) Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM F567	(2011a) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2008) Standard Specification for Fence Fittings
ASTM F883	(2009) Padlocks

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping

KS D 8308	(2001) Zinc Hot Dip Galvanizings
KS F 4009	(2011) Ready-Mixed Concrete

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191/3	(Rev E; Am 1) Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Assembly; G

Location of Gate, Corner, End, and Pull Posts; G

Gate Assembly; G

Gate Hardware and Accessories; G

Erection/Installation Drawings; G

SD-03 Product Data

Fence Assembly

Gate Assembly

Gate Hardware and Accessories

Zinc Coating

PVC Coating

Aluminum Alloy Coating

Fabric

Stretcher Bars

Concrete

GATE POSTS

SD-07 Certificates

Certificates of Compliance; G

SD-08 Manufacturer's Instructions

Fence Assembly

Gate Assembly

Hardware Assembly

Accessories

1.3 ASSEMBLY AND INSTALLATION INSTRUCTIONS

Submit manufacturer's erection/installation drawings and instructions that detail proper assembly and materials in the design for fence, gate, hardware and accessories.

Submit erection/installation drawings along with manufacturer's catalog data for complete fence assembly, gate assembly, hardware assembly and accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.5 QUALITY ASSURANCE

1.5.1 Required Report Data

Submit reports of listing of chain-link fencing and accessories regarding weight in grams (ounces) for zinc coating, thickness of PVC coating, and chemical composition and thickness of aluminum alloy coating.

1.5.2 Certificates of Compliance

Submit certificates of compliance in accordance with the applicable reference standards and descriptions of this section for the following:

a. Zinc coating

b. PVC coating

c. Aluminum alloy coating

d. Fabric

e. Stretcher bars

f. Gate hardware and accessories

g. Concrete

PART 2 PRODUCTS

2.1 GENERAL

Provide fencing materials conforming to the requirements of ASTM A116, ASTM A702, ASTM F626, and as specified.

2.2 ZINC COATING

Provide hot-dip galvanized (after fabrication) ferrous-metal components and accessories, except as otherwise specified.

Provide zinc coating of weight not less than 550 gram per square meter (1.94 ounces per square foot), as determined from the average result of two specimens, when tested in accordance with ASTM A90/A90M.

Provide zinc coating conforming to the requirements of the following:

a. Pipe: FS RR-F-191/3 Class 1 Grade A in accordance with ASTM F1083 or KS D 3507 .

b. Hardware and accessories: ASTM A153/A153M, Table 1 or KS D 8308

c. Surface: ASTM F1043

d. External: Type B-B surface zinc with organic coating, 275 gram per square meter (0.97 ounce per square foot) minimum thickness of acrylated polymer.

e. Internal: Surface zinc coating of 275 gram per square meter (0.97 ounce per square foot) minimum.

Provide galvanizing repair material that is cold-applied zinc-rich coating conforming to ASTM A780/A780M.

2.3 FABRIC

Provide fabric consisting of 3.8 millimeter (No. 9-gage) wires woven into a 25 millimeter (1-inch) diamond mesh, with dimensions of fabric and wire conforming to ASTM A116, ASTM A702 and ASTM F626, with 370 gram per square meter (1.20 ounces per square foot) zinc galvanizing, unless otherwise indicated in contract drawings.

Provide one-piece fabric widths for fence heights up to 3658 millimeter (12 feet).

2.4 TOP AND BOTTOM SELVAGES

Provide knuckled selvages at top and bottom for fabric with 51 millimeter (2 inch) mesh and up to 1524 millimeter (60 inches) high, and if over 1524 millimeter (60 inches) high, provide twisted and barbed top selvage and knuckled bottom selvage.

Knuckle top and bottom selvages for 45 millimeter and 25 millimeter (1-3/4-inch and 1-inch) mesh fabric.

2.5 LINE POSTS

Minimum acceptable line posts are as follows:

Up to 1829 millimeter (6-feet) high:

Grade A: DN50 (1.900 inch) O.D. pipe weighing 4.05 kilogram per linear meter (2.72 pounds per linear foot).

Grade B: DN60 (2.375 inch) O.D. pipe weighing 4.65 kilogram per linear meter (3.12 pounds per linear foot).

Over 1829 millimeter (6-feet) high:

DN50 (2.0 inch) O.D. pipe weighing 5.44 kilogram per linear meter (3.65 pounds per linear foot).

2.6 END, CORNER, AND PULL POSTS

Provide minimally acceptable end, corner, and pull posts as follows:

Up to 1829 millimeter (6 feet) high:

Grade A: DN50 (2.375 inch) O.D. pipe weighing 5.44 kilogram per linear meter (3.65 pounds per linear foot).

Grade B: DN60 (2.375 inch) O.D. pipe weighing 4.65 kilogram per linear meter (3.12 pounds per linear foot).

Over 1829 millimeter (6 feet) high:

Grade A: DN70 (2.875 inch) O.D. pipe weighing 8.62 kilogram per linear meter (5.79 pounds per linear foot).

Grade B: DN70 (2.875 inch) O.D. pipe weighing 6.91 kilogram per linear meter (4.64 pounds per linear foot).

2.7 SLEEVES

Provide sleeves for setting into concrete construction of the same material as post sections, sized 25 millimeter (1-inch) greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

2.8 TOP RAIL

Provide a minimum of DN40 (1.660 inches) O.D. pipe rails. Grade A weighing 3.38 kilogram per linear meter (2.27 pounds per linear foot), unless otherwise indicated in contract drawings. Provide expansion couplings 150 millimeter (6-inches) long at each joint in top rails.

2.9 CENTER RAILS BETWEEN LINE POSTS

For fencing over 1829 millimeter (6-feet) high, provide DN40 (1.660 inches) O.D. pipe center rails, Grade A weighing 3.38 kilogram per linear meter (2.27 pounds per linear foot), unless otherwise indicated in contract drawings.

2.10 POST-BRACE ASSEMBLY

Provide bracing consisting of DN40 (1.660 inches) O.D. pipe Grade A weighing 3.38 kilogram per linear meter (2.27 pounds per linear foot), unless otherwise indicated in contract drawings, and 10 millimeter (3/8 inch) adjustable truss rods and turnbuckles.

2.11 TENSION WIRE

Provide galvanized wire, 3.7 millimeter (No. 7-gage), coiled spring wire, provided at the bottom of the fabric only. Provide zinc coating that weighs not less than 370 gram per square meter (1.2 ounces per square foot), unless otherwise indicated in contract drawings.

2.12 STRETCHER BARS

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 5 by 20 millimeter (3/16 by 3/4 inch), in accordance with ASTM A116, ASTM A702 and ASTM F626.

2.13 POST TOPS

Provide tops that are steel, wrought iron, or malleable iron designed as a weathertight closure cap. Provide one cap for each post, unless equal protection is provided by a combination post-cap and barbed-wire supporting arm. Provide caps with an opening to permit through passage of the top rail.

2.14 STRETCHER BAR BANDS

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over 381 millimeter (15 inches) on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.15 GATE POSTS

Provide a gate post for supporting each gate leaf as follows:

Up to 1829 millimeter (6-feet) wide:

> Provide DN75 (2.875 inch) O.D. pipe Grade A weighing 8.62 kilogram per linear meter (5.79 pounds per linear foot), unless otherwise indicated in contract drawings.

Over 1829 millimeter (6 feet) wide and up to 3962 millimeter (13 feet) wide:

> Provide DN75 (2.875 inch) O.D. pipe Grade A weighing 8.62 kilogram per linear meter (5.79 pounds per linear foot), unless otherwise indicated in contract drawings.

Over 3962 millimeter (13-feet) and up to 5486 millimeter 18-feet) wide:

> Provide DN150 (6.625 inch) O.D. pipe weighing 28.26 kilogram per linear meter (18.97 pounds per linear foot).

Over 5486 millimeter (18-feet) wide:

> Provide DN220 (8.625 inch) O.D. pipe weighing 36.79 kilogram per linear meter (24.70 pounds per linear foot).

2.16 GATES

For gate leaves up to 1829 millimeter (6-feet) high or 1829 millimeter (6-feet) wide, provide perimeter gate frames of DN32 (1.66 inch) O.D. pipe Grade A weighing 3.38 kilogram per linear meter (2.27 pounds per linear foot), unless otherwise indicated in contract drawings.

For gate leaves over 1829 millimeter (6 feet) high or 1829 millimeter (6 feet) wide, provide perimeter gate frames of DN40 (1.90 inch) O.D. pipe Grade A weighing 4.05 kilogram per linear meter (2.72 pounds per linear foot), unless otherwise indicated in contract drawings.

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 381 millimeter (15 inches). Attach hardware with rivets or by other means which provides equal security against breakage or removal.

Provide diagonal cross-bracing, consisting of 10 millimeter (3/8-inch) diameter adjustable-length truss rods on welded gate frames, where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

2.17 GATE HARDWARE AND ACCESSORIES

Provide gate hardware and accessories that conforms to ASTM A116, ASTM A702, ASTM F626, and be as specified:

Provide pressed steel hinges to suit gate size, non-lift-off type, offset to permit 180-degree opening.

Provide latch that permits operation from either side of the gate, with a padlock eye provided as an integral part of the latch.

Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

Provide double gates with a cane bolt and ground-set keeper, with latch or locking device and padlock eye designed as an integral part.

Provide manufacturer's standard heavy-duty track ball bearing hanger sheaves, overhead framing and supports, guides, stays, bracing, and accessories as required for easy operation of manual sliding gates.

2.18 MISCELLANEOUS HARDWARE

Provide miscellaneous hot-dip galvanized hardware as required.

2.19 WIRE TIES

Provide 1.6 millimeter (16-gage) galvanized steel wire for tying fabric to line posts, spaced 300 millimeter (12 inches) on center. For tying fabric to rails and braces, space wire ties 600 millimeter (24 inches) on center. For tying fabric to tension wire, space 2.7 millimeter (0.105-inch) hog rings 600 millimeter (24 inches) on center.

Manufacturer's standard procedure will be accepted if of equal strength and durability.

Provide wire ties constructed of the same material as the fencing fabric. Provide accessories with polyvinyl (PVC) coatings similar to that specified for chain-link fabric or framework.

2.20 CONCRETE

Provide concrete conforming to ASTM C94/C94M or KS F 4009, and obtaining a minimum 28-day compressive strength of 20685 kilopascal (3,000 psi).

2.21 GROUT

Provide grout of proportions one part portland cement to three parts clean, well-graded sand and a minimum amount of water to produce a workable mix.

2.22 PADLOCKS

Provide padlocks conforming to ASTM F883, with chain.

PART 3 EXECUTION

Provide complete installation conforming to ASTM F567.

3.1 GENERAL

Ensure final grading and established elevations are complete prior to commencing fence installation.

3.2 EXCAVATION

Provide excavations for post footings which are drilled holes in virgin or compacted soil, of minimum sizes as indicated.

Space footings for line posts 3048 millimeter (10 feet) on center maximum and at closer intervals when indicated, with bottoms of the holes approximately 75 millimeter (3-inches) below the bottoms of the posts. Set bottom of each post not less than 915 millimeter (36-inches) below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads.

Remove excavated soil from Government property, unless otherwise indicated in contract drawings.

When solid rock is encountered near the surface, drill into the rock at least 305 millimeter (12 inches) for line posts and at least 457 millimeter (18 inches) for end, pull, corner, and gate posts. Drill holes at least 25.4 millimeter (1 inch) greater in diameter than the largest dimension of the placed post.

If solid rock is below the soil overburden, drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

3.3 SETTING POSTS

Remove loose and foreign materials from holes and the soil moistened prior to placing concrete.

Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved.

Grout all posts set into sleeved holes in concrete with an approved grouting material.

Maintain vertical alignment of posts set in concrete construction until concrete has set.

3.3.1 Earth and Bedrock

Provide concrete bases of dimensions indicated except in bedrock. Compact concrete to eliminate voids, and finish to a dome shape. In bedrock, set posts with a minimum of 25.4 mm (1 inch) of grout around each post. Work grout into hole to eliminate voids, and finish to a dome shape.

3.3.2 Concrete Slabs and Walls

Set posts into zinc-coated sleeves, set in concrete slab or wall, to a minimum depth of 305 mm (12 inches). Fill sleeve joint with lead, nonshrink grout, or other approved material. Set posts for support of removable fence sections into sleeves that provide a tight sliding joint and hold posts aligned and plumb without use of lead or setting material.

3.3.3 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 305 mm (12 inches) below top of fence, and two diagonal tension rods, unless otherwise indicated in contract drawings.

3.4 CONCRETE STRENGTH

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

Take samples and test concrete to determine strength as specified.

3.5 TOP RAILS

Provide top rails that run continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by the fencing manufacturer.

3.6 CENTER RAILS

Provide single piece center rails between posts set flush with posts on the fabric side, using special offset fittings where necessary.

3.7 BRACE ASSEMBLY

Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at mid-height of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under proper tension.

Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

3.8 TENSION WIRE INSTALLATION

Install tension wire by weaving them through the fabric and tying them to each post with not less than 3.9 millimeter (7-gage) galvanized wire or by securing the wire to the fabric with 3.5 millimeter (10-gage) ties or clips spaced 610 millimeter (24 inches) on center.

3.9 FABRIC INSTALLATION

Provide fabric in single lengths between stretch bars with bottom barbs placed approximately 51 millimeter (2 inches) above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed.

Ensure fabric remains under tension after the pulling force is released.

3.10 STRETCHER BAR INSTALLATION

Thread stretcher bars through or clamped to fabric 102 millimeter (4 inches) on center and secured to posts with metal bands spaced 381 millimeter (15 inches) on center.

3.11 GATE INSTALLATION

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

3.12 TIE WIRES

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.13 FASTENERS

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.14 ZINC-COATING REPAIR

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.15 TOLERANCES

Provide posts that are straight and plumb within a vertical tolerance of 6.35 millimeter (1/4 inch) after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 12.7 millimeter (1/2 inch) deviation from the established centerline between line posts.

Repair defects as directed.

3.16 SITE PREPARATION

3.16.1 Clearing and Grading

Clear fence line of trees, brush, and other obstacles to install fencing. Establish a graded, compacted fence line prior to fencing installation.

3.17 FENCE INSTALLATION

Install fence on prepared surfaces to line and grade indicated. Secure fastening and hinge hardware in place to fence framework by peening or welding. Allow for proper operation of components. Coat peened or welded areas with a repair coating matching original coating. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.17.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 3.048 m (10 feet) on center. Provide gate posts spaced as necessary for size of gate openings. Do not exceed 152.4 m (500 feet) on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 0.26 rad (15 degrees) or more, or for abrupt changes in grade. Provide drawings showing location of gate, corner, end, and pull posts.

3.17.2 Top and Bottom Tension Wire

Install top and bottom tension wires before installing chain-link fabric, and pull wires taut. Place top and bottom tension wires within 203 mm (8 inches) of respective fabric line.

3.18 ACCESSORIES INSTALLATION

3.18.1 Post Caps

Design post caps to accommodate top rail. Install post caps as recommended by the manufacturer.

3.18.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

3.19 GROUNDING

Ground fencing as indicated on drawings.

Ground all fences crossed by overhead power lines in excess of 600 volts, and all electrical equipment attached to the fence. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within 15 m (50 feet) of the fence, and where the fence alignment changes more than 15 degrees. Distance between grounding locations shall not exceed 198 m (650 feet). Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by power lines of 600 volts or more at or near the point of crossing and at distances not exceeding 45 m (150 feet) on each side of crossing. Provide ground conductor consisting of No. 8 AWG solid copper wire. Provide copper-clad steel rod grounding electrodes 19 mm (3/4 inch) by 3.05 m (10 foot) long. Drive electrodes into the earth so that the top of the electrode is at least 152 mm (6 inches) below the grade. Where driving is impracticable, bury electrodes a minimum of 305 mm (12 inches) deep and radially from the fence, with top of the electrode not less than 610 mm (2 feet) or more than 2.4 m (8 feet) from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Total resistance of the fence to ground cannot exceed 25 ohms

3.20 SECURITY

Install new security fencing, remove existing security fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer and cognizant Security Officer.

3.21 CLEANUP

Remove waste fencing materials and other debris from the work site.

-- End of Section --

SECTION 32 84 23

UNDERGROUND SPRINKLER SYSTEMS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1012	(2009) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent - (ANSI approved 2009)
ASSE 1013	(2011) Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)
ASSE 1020	(2004; Errata 2004; Errata 2004) Performance Requirements for Pressure Vacuum Breaker Assembly (ANSI Approved 2004)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C509	(2009) Resilient-Seated Gate Valves for Water Supply Service
AWWA C606	(2011) Grooved and Shouldered Joints
AWWA C901	(2008) Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13mm) Through 3 In. (76 mm), for Water Service

ASME INTERNATIONAL (ASME)

ASME B1.2	(1983; Errata 1992; R 2007) Gages and Gaging for Unified Inch Screw Threads
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B43	(2014) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2287	(2011) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM D2464	(2013) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with

	Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3261	(2012; E 2014) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM F441/F441M	(2013; E 2013) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR Manual	(1988e9) Manual of Cross-Connection Control

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI WH 201	(2010) Water Hammer Arresters Standard

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-51145	(Rev D; Notice 1) Flux, Soldering, Non-Electronic, Paste and Liquid

1.2 SYSTEM DESCRIPTION

Provide a system that operates with a minimum water pressure of 138 kPa (20 psi) at connection to backflow prevention device and 55.2 kPa (8 psi) at the last head in each zone. Submit Design Analysis and Calculations verifying that system will provide the irrigation requirements.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Sprinkler System

SD-03 Product Data

Framed Instructions
Field Training
Sprinkler System
Spare Parts
Design Analysis and Calculations

SD-06 Test Reports

Field Tests

SD-07 Certificates

Sprinkler System

SD-10 Operation and Maintenance Data

Sprinkler System

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity, and temperature variation; direct sunlight (in the case of plastic or rubber materials); and dirt, dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than the start of the field tests. Include with the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer who has produced similar systems that have performed well for a minimum period of 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Each item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Additional Stock

Provide the following extra stock: Two sprinkler heads of each size and type, two valve keys for operating manual valves, two wrenches for removing and installing each type of head, two quick coupler keys and hose swivels, and four irrigation controller housing keys.

2.2 PIPING MATERIALS

2.2.1 Copper Tubing and Associated Fittings

Tubing shall conform to requirements of ASTM B88M (ASTM B88), Type K. Fittings shall conform to ASME B16.22 and ASME B16.18, solder joint. Solder shall conform to ASTM B32 95-5 tin-antimony. Flux shall conform to CID A-A-51145, Type I. Grooved mechanical joints and fittings shall be designed for not less than 862 kPa (125 psig) service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 110 degrees C (230 degrees F). Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A183.

2.2.2 Red Brass Pipe and Associated Fittings

Pipe shall conform to requirements of ASTM B43, regular. Fittings shall be Class 250, cast bronze threaded conforming to the requirements of ASME B16.15.

2.2.3 Galvanized Steel Pipe and Associated Fittings

Pipe shall conform to requirements of ASTM A53/A53M, Schedule 40. Fittings shall be Class 150 conforming to requirements of ASME B16.3.

2.2.4 Polyvinyl Chloride (PVC) Pipe, Fittings and Solvent Cement

2.2.4.1 PVC Pipe

Pipe shall conform to the requirements of ASTM D1785, PVC 1120 Schedule 40, 80; or ASTM D2241, PVC 1120 SDR 21, Class 200.

2.2.4.2 PVC Fittings

Solvent welded socket type fittings shall conform to requirements of ASTM D2466, Schedule 40. Threaded type fittings shall conform to requirements of ASTM D2464, Schedule 80.

2.2.4.3 Solvent Cement

Solvent cement shall conform to the requirements of ASTM D2564.

2.2.5 Polyethylene (PE) Plastic Piping

Pipe shall conform to AWWA C901, outside diameter base with dimension ratio (DR) of 9.3 to provide 1034 kPa (150 psi) minimum pressure rating. Fittings shall conform to ASTM D3261, DR of 9.3.

2.2.6 Dielectric Fittings

Dielectric fittings shall conform to ASTM F441/F441M, Schedule 80, CPVC threaded pipe nipples, 100 mm (4 inch) minimum length.

2.2.7 Emitter Hose and Distribution Tubing

Emitter hose and distribution tubing shall conform to ASTM D2287, maximum inside diameter of 13 mm (1/2 inch), minimum wall thickness of 2.286 mm (90 mils), vinyl plastic extruded from non-rigid chloride, integrally algae-resistant, homogeneous throughout, smooth inside and outside, free from foreign materials, cracks, serrations, blisters and other effects. Slip fittings shall be provided.

2.3 SPRINKLER AND EMITTER HEADS

2.3.1 Pop-Up Spray Heads

2.3.1.1 General Requirements

Pop-up spray heads lay flush with housing, then pop up when water pressure 138 kPa (20 psi) is activated in system. The rising member supporting the nozzle shall be identical on full, half, third or quarter pattern sprinklers so that nozzles will be interchangeable. The sprinkler head shall be designed to be adjustable for coverage and flow. The nozzle shall be removable so head does not have to be removed for flushing or cleaning. Nozzle shall rise a minimum of 100 mm (4 inches) above the body. The body shall be constructed with a 13 mm (1/2 inch) female thread for installation in a fixed underground pipe system.

2.3.1.2 Shrubbery Sprinkler Heads

Sprinkler heads shall be conical spray with adjustable or non-adjustable coverage and designed for permanent aboveground mounting on riser or pop-ups at a height compatible with ground covers. Provide brass nozzles.

2.3.2 Rotary Pop-Up Sprinklers

Sprinklers shall be capable of covering area with pressure, distribution rate, trajectory, and maximum height of spray as indicated on contract drawings. Construction shall be high impact molded plastic with filter screen, reducible watering radius, choice of up to four nozzles and adjustable radius capabilities.

2.3.3 Bubbler Sprinkler Heads

Heads shall be multiple-spray bubbler with adjustable flow and designed for permanent aboveground mounting on risers.

2.3.4 Surface Connected Lawn Sprinkler Heads

Heads shall be an impulse type with or without sled, ring, or wheel base; multiple T Type; a rotary type with sled, spike or wheel base; or oscillating type with wheel or sled base.

2.3.5 Emitter Heads

Emitter heads shall be self-cleaning, pressure compensating diaphragm with one or six self-piercing barbed outlets; each capable of emitting from 1 to 8 L/hour (1/4 to 2 gallons/hour) flow. Emitter body shall be ultraviolet stabilized, algae, and heat resistant plastic construction.

2.4 VALVES

2.4.1 Gate Valves, Less than 80 mm (3 inches)

Gate valves shall conform to the requirements of MSS SP-80, Type 1, Class 150, threaded or soldered ends.

2.4.2 Gate Valves, 80 mm (3 inches) and Larger

Gate valves shall conform to the requirements of AWWA C509 and have encapsulated resilient wedge, parallel seats, non-rising stems, and open by counterclockwise turning. End connections shall be flanged. Interior construction of valves shall be bronze including stem containing a maximum 2 percent aluminum and maximum 16 percent zinc.

2.4.3 Angle Valves, Less Than 65 mm (2-1/2 inches)

Angle valves shall conform to the requirements of MSS SP-80, Type 3, Class 150 threaded or soldered ends.

2.4.4 Angle Valves, 65 mm (2-1/2 inches and Larger

Angle valves shall conform to the requirements of MSS SP-85, Type II, Class 250 threaded or flanged ends.

2.4.5 Quick Coupling Valves

Quick coupling valves shall have brass parts and shall be two-piece unit consisting of a coupler water seal valve assembly and a removable upper body to allow spring and key track to be serviced without shutdown of main. Lids shall be lockable vinyl with spring for positive closure on key removal.

2.4.6 Remote Control Valves, Electrical

Remote control valves shall be solenoid actuated globe valves of 19 to 80 mm (3/4 to 3 inch) size, suitable for voltage as indicated in contract drawings, and designed to provide for shut-off in event of power failure. Valve shall be cast bronze or brass or plastic housing suitable for service at 1034 kPa (150 psi) operating pressure with external flow control adjustment for shut-off capability, external plug at diaphragm chamber to enable manual operation, filter in control chamber to prevent valve body clogging with debris, durable diaphragm, and accessibility to internal parts without removing valve from system.

2.4.7 Drain Valves

2.4.7.1 Manual Valves

Manual valves shall conform to requirements of MSS SP-80, Type 3, Class

150 threaded or soldered ends for sizes less than 65 mm (2-1/2 inches) and MSS SP-85, Type II, Class 250 threaded or flanged ends for sizes 65 mm (2-1/2 inches) and larger.

2.4.7.2 Automatic Valves

Automatic valves shall be brass or plastic, spring loaded ball drip type, Class 150 (150 pounds) and threaded ends, designed to close at 18 kPa (6 foot) pressure head with positive seal at 21 kPa (3 psi) pressure or greater and be open to drain at less than 21 kPa (3 psi) pressure.

2.4.8 Pressure Regulating Master Valve

Pressure regulating master valve shall be automatic mechanical self-cleaning, self-purging control system having an adjustable pressure setting operated by a solenoid, with operating voltage and current as indicated on contract drawings. Valve shall close slowly and be free of chatter in each diaphragm position, have manual flow stem to adjust closing speed and internal flushing, and one inlet taps capable of being installed as a straight pattern valve. Body shall be cast bronze or brass with removable brass seat serviceable from top without removing valve body from system. Valve shall operate at 1034 kPa (150 psi) working pressure and pilot range from 70 to 875 kPa (10 to 125 psi).

2.4.9 Backflow Preventers

Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be tested, approved, and listed in accordance with FCCCHR Manual. Backflow preventers with intermediate atmospheric vent shall be in accordance with ASSE 1012. Reduced pressure principle backflow preventers shall be in accordance with ASSE 1013.

2.4.9.1 Pressure Type Vacuum Breaker

Vacuum breaker shall conform to the requirements of ASSE 1020 and shall be bronze or brass construction, with one or two check valves, vacuum relief, inlet and discharge shut-offs valves, field test cocks, and vacuum relief opening of greater diameter than unit.

2.4.9.2 Reduced Pressure Type Backflow Preventers

Backflow preventers shall be Class 150 (150 pound) flanged cast iron mounted gate valve and strainer, 304 stainless steel or bronze, internal parts. Total pressure drop through complete assembly shall be a maximum of 70 kPa (10 psi) at rated flow. Piping shall be red brass or galvanized steel pipe and fittings. Strainers shall be bronze or brass construction with gasket caps. Units shall have 200-mesh stainless steel screen elements.

2.5 ACCESSORIES AND APPURTENANCES

2.5.1 Valve Keys for Manually Operated Valves

Valve keys shall be 13 mm (1/2 inch) diameter by 1 m (3 feet) long, tee handles and keyed to fit valves.

2.5.2 Valve Boxes and Concrete Pads

2.5.2.1 Valve Vaults

Valve boxes shall be cast iron, plastic lockable, or precast concrete for each gate valve, manual control valve and remote control valve. Vault sizes shall be adjustable for valve used. Cast the word "IRRIGATION" on the cover. Shaft diameter of vault shall be minimum 130 mm (5-1/4 inches). Cast iron vault shall have bituminous coating.

2.5.2.2 Concrete Pads

Concrete pads shall be precast or cast-in-place reinforced concrete construction for reduced pressure type backflow preventers.

2.5.3 Pressure Gauges

Pressure gauges shall conform to requirements of ASME B40.100, single style pressure gauge for water with 115 mm (4-1/2 inch) dial brass or aluminum case, bronze tube, gauge cock, pressure snubber, and siphon. Scale range shall be suitable for irrigation sprinkler systems.

2.5.4 Service Clamps

Service clamps shall be bronze flat, double strap, with neoprene gasket or "O"-ring seal.

2.5.5 Water Hammer Arresters

Water hammer arrester shall conform to the requirements of PDI WH 201; stainless steel construction with an encased and sealed bellows compression chamber.

2.5.6 Emitter Head Accessories

2.5.6.1 Strainer

Strainer shall be provided at inlet to each drip line. Strainer shall have stainless steel screen having equivalent of 140-mesh filtration capacity and incorporate flush valves within strainer to clean screen without disassembling unit.

2.5.6.2 Pressure Regulator

Pressure regulator shall be provided at each drip system if supply pressure exceeds 350 kPa (50 psi).

2.5.6.3 Riser Adapters

Riser adapters shall be provided with a rigid piping system.

2.5.6.4 Tubing Stakes

Tubing stakes shall be plastic coated steel, or other non-corrosive strong material to secure tubing.

2.5.6.5 Emitter Outlet Check Valve (Bug Cap)

Check valves shall be provided at end of each emitter outlet distribution line. Valves shall permit free flow of water with minimum restriction; prevent back siphoning, entry of insects, and contamination into outlet ports.

2.5.6.6 Access Sleeve

Access sleeve shall be provided at buried emitters placed in covered boxes. Lids of access sleeve shall be secured with removable lugs. Drip hose in both vertical and horizontal axis shall be secured.

2.5.6.7 Closure Caps

Closure caps shall be in accordance with manufacturer's recommendations.

2.6 AUTOMATIC CONTROLLERS, ELECTRICAL

Controller shall conform to the requirements of NEMA ICS 2 with 120 or220-volt single phase service, operating with indicated stations, and grounded chassis. Enclosure shall conform to NEMA ICS 6 Type 3R, with locking hinged cover, pedestal-mounted or wall-mounted. Controller shall be programmed for various schedules by setting switches and dials equipped with the following features: A switch for each day of week for three schedules, allowing each station to be scheduled individually as to days of watering; a minute switch for each station with a positive increment range of 3 to 60 minutes, set time within one percent; a switch allowing selected schedules to be repeated after each completion of initial watering schedule and allowing each operation to be scheduled throughout a 24-hour day; a circuit breaker for surge protection; and circuit for a 9-volt rechargeable NiCad battery.

2.7 ELECTRICAL WORK

Wiring and rigid conduit for electrical power shall be in accordance with NFPA 70, and Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.8 CONCRETE MATERIALS

Concrete shall have a compressive strength of 17 MPa (2500 psi) at 28 days as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.9 WATER SUPPLY MAIN MATERIALS

Tapping sleeves, service cut off valves, and connections to water supply mains shall be in accordance with Section 33 11 00 WATER DISTRIBUTION.

2.10 INSULATING JOINTS

Insulating joints and dielectric fittings shall be in accordance with Section 33 11 00 WATER DISTRIBUTION.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install Sprinkler System after site grading has been completed. Perform excavation, trenching, and backfilling for sprinkler system in accordance with the applicable provisions of Section 31 00 00 EARTHWORK, except as modified herein.

a. Submit detail drawings for valves, sprinkler heads, backflow preventers, automatic controllers, emitter heads, and water hammer arresters. Include on the drawings a complete list of equipment and materials, and manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Also show on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function as a unit. Show on the drawings proposed system layout, type and number of heads and emitters, zone valves, drain pockets, backflow devices, controllers, and mounting details of controllers.

b. Submit detailed procedures defining the Contractor's provisions for accident prevention, health protection, and other safety precautions for the work to be done. Submit the material supplier's or equipment manufacturer's statement that the supplied material or equipment meets specified requirements. Each certificate shall be signed by an official authorized to certify in behalf of material supplier or product manufacturer and shall identify quantity and date or dates of shipment or delivery to which the certificates apply. Include As-built Drawings which provide current factual information showing locations of mains, heads, valves, and controllers including deviations from and amendments to the drawings and changes in the work.

c. Submit one hard copy & one digital copy (.pdf - text searchable) of operation and maintenance manuals for the equipment furnished. Submit digital copy prior to field testing and the hard copy upon acceptance. Manuals shall be approved prior to the field training course. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

d. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout, simplified wiring and control diagrams of the system as installed, and system programming schedule.

3.2.1 Trenching

Hand excavate trench around roots to pipe grade when roots of 50 mm (2 inches) diameter or greater are encountered. Trench width shall be 100 mm (4 inches) minimum or 1.5 times diameter of pipe, whichever is wider. Backfill shall be hand tamped over excavation. When rock is encountered, trench shall be excavated 100 mm (4 inches)deeper and backfilled with silty sand (SM) or well-graded sand (SW) to pipe grade. Trenches shall be kept free of obstructions and debris that would damage pipe. Subsoil shall not be mixed with topsoil. Existing concrete walks, drives and other obstacles shall be bored at a depth conforming to bottom of adjacent trenches. Pipe sleeves for bored pipe shall be two pipe diameters larger than sprinkler pipe.

3.2.2 Piping System

3.2.2.1 Cover

Underground piping shall be installed to meet the minimum depth of backfill cover specified.

3.2.2.2 Clearances

Minimum horizontal clearances between lines shall be 100 mm (4 inches) for pipe 50 mm (2 inches) and less; 300 mm (12 inches) for 65 mm (2-1/2 inches) and larger. Minimum vertical clearances between lines shall be 25 mm (1 inch).

3.2.2.3 Minimum Slope

Minimum slope shall be 50 mm per 10 m (6 inches per 100 feet) in direction of drain valves.

3.2.3 Piping Installation

3.2.3.1 Polyvinyl Chloride (PVC) Pipe

a. Solvent-cemented joints shall conform to the requirements of ASTM D2855.

b. Threaded joints shall be full cut with a maximum of three threads remaining exposed on pipe and nipples. Threaded joints shall be made tight without recourse to wicks or fillers, other than polytetrafluoroethylene thread tape.

c. Piping shall be joined to conform with requirements of ASTM D2774 or ASTM D2855, and pipe manufacturer's instructions. Pipe shall be installed in a serpentine (snaked) manner to allow for expansion and contraction in trench before backfilling. Pipes shall be installed at temperatures over 5 degrees C (40 degrees F).

3.2.3.2 Soldered Copper Tubing

Pipe shall be reamed and burrs removed. Contact surfaces of joint shall be cleaned and polished. Flux shall be applied to male and female ends. End of tube shall be inserted into fittings full depth of socket. After soldering, a solder bead shall show continuously around entire joint circumference. Excess acid flux shall be removed from tubes and fittings.

3.2.3.3 Threaded Brass or Galvanized Steel Pipe

Prior to installation, pipe shall be reamed. Threads shall be cut in conformance with ASME B1.2. Pipe joint compound shall be applied to male end only.

3.2.3.4 Insulating Joints

Insulating and dielectric fittings shall be provided where pipes of dissimilar metal are joined and at connections to water supply mains as shown. Installation shall be in accordance with Section 33 11 00 WATER DISTRIBUTION.

3.2.3.5 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Grove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with the coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.2.4 Installation of Valves

3.2.4.1 Manual Valves

Valves shall be installed in a valve box extending from grade to below valve body, with a minimum of 100 mm (4 inches) cover measured from finish grade to top of valve stem.

3.2.4.2 Automatic Valves

Valve shall be set plumb in a valve box extending from grade to below valve body, with minimum of 100 mm (4 inch) cover measured from grade to top of valve. Automatic valves shall be installed beside sprinkler heads with a valve box.

3.2.4.3 Drain Valves

Entire system shall be manually or automatically drainable. Low points of system shall be equipped with drain valve draining into an excavation containing 0.03 cubic meter (1 cubic foot) gravel. Gravel shall be covered with building paper then backfilled with excavated material and 150 mm (6 inches) of topsoil.

3.2.5 Sprinklers and Quick Coupling Valves

Sprinklers and valves shall be installed plumb and level with terrain.

3.2.6 Installation of Drip Irrigation System

3.2.6.1 Emitter Hose

Emitter laterals shall be buried 150 mm (6 inches) deep. Connections shall be solvent welded in accordance with manufacturer's recommendation to standard weight Schedule 40 PVC fittings and bushings. Hose shall be installed in a serpentine manner. When cutting hose, shearing tool such as a pipe cutter, knife, or shears shall be used. Manufacturer's recommended tool and procedures when punching hose for emitters shall be followed.

3.2.6.2 Emitter Heads

Emitters shall be installed in a plastic emitter box. Emitter on a rigid PVC nipple shall be connected to PVC drip lateral with a tee or elbow. Tubing shall be attached to barbed fitting and daylight distribution tubing at root ball secured with stake, with bug cap at end of secured distribution tubing. After installing emitters and before operating system, end of drip lateral shall be opened and flushed clean. The number of emitters on a line shall not exceed manufacturer's recommendations for that hose or distribution tubing size and length.

3.2.6.3 Tubing Stakes

Main irrigation line shall be secured with stakes where line is aboveground. Stakes shall be spaced to ensure that hose does not shift location in presence of foot traffic, operations, gravity on slope installations, or environmental effects. Discharge of the emitter distribution tubing shall be staked to ensure that discharge point of emitter will be maintained at specified position in relation to plant material to be irrigated.

3.2.7 Backflow Preventers

Backflow preventer shall be installed in new connection to existing water distribution system, between connection and control valves. Backflow preventer shall be installed with concrete pads.

3.2.7.1 Pressure Type Vacuum Breaker

Pressure type vacuum breaker shall be installed 300 mm (12 inches) above highest head.

3.2.7.2 Reduced Pressure Type

Pipe lines shall be flushed prior to installing reduced pressure device; device shall be protected by a strainer located upstream. Device shall not be installed in pits or where any part of device could become submerged in standing water.

3.2.8 Control Wire and Conduit

3.2.8.1 Wires

Low voltage wires may be buried beside pipe in same trench. Rigid conduit shall be provided where wires run under paving. Wires shall be number tagged at key locations along main to facilitate service. One control circuit shall be provided for each zone and a circuit to control sprinkler system.

3.2.8.2 Loops

A 300 mm (12 inch) loop of wire shall be provided at each valve where controls are connected.

3.2.8.3 Expansion and Contraction

Multiple tubes or wires shall be bundled and taped together at 3 m (10 foot) intervals with 300 mm (12 inch) loop for expansion and contraction.

3.2.8.4 Splices

Electrical splices shall be waterproof.

3.2.9 Automatic Controller

Exact field location of controllers shall be determined before installation. Coordinate the electrical service to these locations. Install in accordance with manufacturer's recommendations and NFPA 70.

3.2.10 Thrust Blocks

Concrete shall be placed so that sides subject to thrust or load are against undisturbed earth, and valves and fittings are serviceable after concrete has set. Thrust blocks shall be as specified in Section 33 11 00 WATER DISTRIBUTION.

3.2.11 Backfill

3.2.11.1 Minimum Cover

Depth of cover shall be 300 mm (12 inches) for 32 mm (1-1/4 inch) pipe or smaller; 300 mm (12 inches) for 40 to 50 mm (1-1/2 to 2 inch) pipe; 450 mm (18 inches) for 65 mm (2-1/2 inch) pipe or larger; 1000 mm (36 inches) for pipes under traffic loads, farm operations, and freezing temperatures; and 300 mm (12 inches) for low-voltage wires. Remainder of trench or pipe cover shall be filled to within 80 mm (3 inches) of top with excavated soil, and compact soil with plate hand-held compactors to same density as undisturbed adjacent soil.

3.2.11.2 Restoration

Top 80 mm (3 inches) shall be filled with topsoil and compacted with same density as surrounding soil. Lawns and plants shall be restored in accordance with Sections 32 92 19 SEEDING, 32 92 23 SODDING, and Section 32 93 00 EXTERIOR PLANTS.

3.2.12 Adjustment

After grading, seeding, and rolling of planted areas, sprinkler heads shall be adjusted flush with finished grade. Adjustments shall be made by providing new nipples of proper length or by use of heads having an approved device, integral with head, which will permit adjustment in height of head without changing piping.

3.2.13 Disinfection

Sprinkler system fed from a potable water system shall be disinfected upstream of backflow preventer in accordance with Section 33 11 00 WATER DISTRIBUTION.

3.2.14 Cleaning of Piping

Prior to the hydrostatic and operation tests, the interior of the pipe shall be flushed with clean water until pipe is free of all foreign materials. Flushing and cleaning out of system pipe, valves, and components shall not be considered completed until witnessed and accepted by Contracting Officer.

3.3 FRAMED INSTRUCTIONS

Post framed instructions, containing wiring and control diagrams under glass or in laminated plastic, where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. Post the framed instructions before acceptance testing of the system. Submit labels, signs, and templates of operating instructions that are required to be mounted or installed on or near the product for normal, safe operation. After as-built drawings are approved by Contracting Officer, prepare controller charts and programming schedule. One chart for each controller shall be supplied. Chart shall be a reduced drawing of actual as-built system that will fit the maximum dimensions inside controller housing. Black line print for chart and a different pastel or transparent color shall indicate each station area of coverage. After chart is completed and approved for final acceptance, chart shall be sealed between two 0.505 mm (20 mil) pieces of clear plastic.

3.4 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members for a total period of 3 hours of normal working time and starting after the system is functionally complete but prior to final acceptance tests. Submit information describing training to be provided, training aids to be used, samples of training materials to be provided, and schedules and notification of training. Field training shall cover all of the items contained in the operating and maintenance manuals.

3.5 FIELD TESTS

Provide all instruments, equipment, facilities, and labor required to conduct the tests. Submit performance test reports, in booklet form, showing all field tests performed to adjust each component; and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of control valves.

3.5.1 Hydrostatic Pressure Test

Piping shall be tested hydrostatically before backfilling and proved tight at a hydrostatic pressure of 1034 kPa (150 psi) without pumping for a period of one hour with an allowable pressure drop of 35 kPa (5 psi). If hydrostatic pressure cannot be held for a minimum of 4 hours, make adjustments or replacements and repeat the tests until satisfactory results are achieved and accepted by the Contracting Officer.

3.5.2 Leakage Tests

Leakage tests for service main shall be in accordance with Section 33 11 00 WATER DISTRIBUTION.

3.5.3 Operation Test

At conclusion of pressure test, sprinkler heads or emitter heads, quick coupling assemblies, and hose valves shall be installed and entire system tested for operation under normal operating pressure. Operation test consists of the system operating through at least one complete programmed cycle for all areas to be sprinkled.

3.6 CLEANUP

Upon completion of installation of system, all debris and surplus materials resulting from the work shall be removed.

-- End of Section --

SECTION 32 84 24

IRRIGATION SPRINKLER SYSTEMS
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Std 598	(2009) Valve Inspecting and Testing

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1010	(2004) Performance Requirements for Water Hammer Arresters (ANSI approved 2004)
ASSE 1020	(2004; Errata 2004; Errata 2004) Performance Requirements for Pressure Vacuum Breaker Assembly (ANSI Approved 2004)
ASSE Series 5000	(2009) Cross-Connection Control Professional Qualification Standard

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C511	(2007) Standard for Reduced-Pressure Principle Backflow Prevention Assembly
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C901	(2008) Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13mm) Through 3 In. (76 mm), for Water Service
AWWA M14	(2004; 3rd Ed) Manual: Recommended Practice for Backflow Prevention and Cross-Connection Control

ASME INTERNATIONAL (ASME)

ASME B1.2	(1983; Errata 1992; R 2007) Gages and Gaging for Unified Inch Screw Threads
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint

	Pressure Fittings
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B43	(2014) Standard Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2287	(2011) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM D2464	(2013) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

ASTM D3261	(2012; E 2014) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM F441/F441M	(2013; E 2013) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2014) Plastics Piping System Components and Related Materials

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-51145	(Rev D; Notice 1) Flux, Soldering, Non-Electronic, Paste and Liquid

UNDERWRITERS LABORATORIES (UL)

UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, and Section

26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, applies to this section, with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

This system is designed with water pressure minimum and maximum at connection to main meter at the last head in each zone, as indicated in contract drawings. Provide a system pressure calculations and irrigation requirements of the area. If pressure falls above or below indicated values, Contractor shall notify Contracting Officer. For Irrigation Sprinkler System, indicate the following:

a. Head, piping, valve, controller, sensor layout.

b. Pipe, valve, backflow preventer, and controller.

c. Invert elevations. Indicate obstructions interfering with operation.

d. Water source equipment, including existing mains, piping, valves and meters.

e. System and supply pressures.

f. Indicate wiring diagram between existing power source and controller/water pump.

g. Number and extent of control valve circuits.

h. Provide details of all irrigation components and accessories.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Irrigation sprinkler system

Drawings including irrigation legend prepared by a licensed, registered or certified Landscape Architect or Irrigation Specialist.

SD-03 Product Data

Piping materials, tubing, and fittings

Valves and accessories

Sprinkler heads

Backflow preventers

Automatic controller

Solvent cement

Control wiring

Drip irrigation equipment and accessories

Water hammer arresters

Water meter

Rain shut-off device

Freeze shut-off device

Soil moisture sensor

Tapping tee

Valve boxes and lids

Drip head accessories

SD-05 Design Data

System pressure calculations

Irrigation requirements

SD-06 Test Reports

Valves, and accessories tests

Backflow preventers

Pressure test

Operation test

Including verification of sprinkler head layout

Submit record of pressure tests conducted on recording gage.

SD-07 Certificates

Backflow preventers

ASSE Series 5000, Submit a certificate of Full Approval or a current Certificate of Approval from FCCCHR List for size, and make of backflow preventer being provided for this project. A Certificate of Provisional Approval will not be acceptable.

SD-08 Manufacturer's Instructions

Automatic controller

Sprinkler heads

Piping materials

Tubing and fittings.

Backflow preventers

Valves

Solvent cement

Control wiring

Drip irrigation and accessories

Water hammer arresters

Water meter

Rain shut-off device

Freeze shut-off device

Soil moisture sensor

Submit mounting details for automatic controllers.

SD-10 Operation and Maintenance Data

Piping materials and fittings, Data Package 2; G

Sprinkler heads and accessories, Data Package 2; G

Backflow preventers, Data Package 2; G

Valves, Data Package 2; G

Automatic controller, Data Package 2; G

Drip irrigation and accessories, Data Package 2; G

Water hammer arresters, Data Package 2; G

Water meter, Data Package 2; G

Rain shut-off device, Data Package 2; G

Freeze shut-off device, Data Package 2; G

Soil moisture sensor, Data Package 2; G2

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Include troubleshooting procedures with respect to valve and controller problems.

SD-11 Closeout Submittals

Controller Charts

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver materials in original rolls, packages, cartons, and containers with the name of manufacturer, brand, and model. Inspect materials delivered to the site for damage.

1.5.2 Storage

Store materials on site in enclosures or under protective covering. Store plastic piping and rubber gaskets under cover out of direct sunlight. Do not store materials directly on ground. Keep inside of pipes and fittings free from dirt and debris.

1.5.3 Handling

Handle and carry pipe, fittings, valves, and accessories in such a manner as to ensure delivery to trench in sound undamaged condition. Do not drag pipe.

1.6 EXTRA STOCK

a. 2 additional sprinkler heads (nozzles, bodies, screens, pressure compensating devices) of each size and type;

b. 2 valve keys for operating manual valves;

c. 2 wrenches for removing and installing each type of head;

d. 2 quick coupler keys and hose swivels;

e. 4 irrigation controller housing keys.

f. 4 irrigation controller enclosure keys; and

g. 2 hand-held remotes compatible with controller system.

1.7 QUALITY ASSURANCE

1.7.1 Required Test

Submit tests signed by an authorized official of a testing laboratory of sprinkler head, valve, automatic controller, emitter heads, vacuum breaker, backflow preventer, and water hammer arrester.

PART 2 PRODUCTS

2.1 PIPING MATERIALS

2.1.1 Copper Tubing and Associated Fittings

2.1.1.1 Tubing

ASTM B88M (ASTM B88), Type K.

2.1.1.2 Fittings

ASME B16.22 and ASME B16.18, solder joint. Solder, ASTM B32 alloy Grade

Sn95 or Sn94. Flux, CID A-A-51145, Type I.

2.1.2 Red Brass Pipe and Associated Fittings

2.1.2.1 Pipe

ASTM B43, regular.

2.1.2.2 Fittings

ASME B16.15, Class 250, cast bronze threaded.

2.1.3 Galvanized Steel Pipe and Associated Fittings

2.1.3.1 Pipe

ASTM A53/A53M, Schedule 40.

2.1.3.2 Fittings

ASME B16.3, Class 150.

2.1.4 Polyvinyl Chloride (PVC) Pipe, Fittings and Solvent Cement

NSF/ANSI 14, seal of approval for potable water.

2.1.4.1 Pipe

ASTM D1785, PVC 1120 Schedule , 80; or ASTM D2241, PVC 1120 SDR 21, , Class 200.

2.1.4.2 Fittings

a. Solvent Welded Socket Type: ASTM D2466, Schedule 40.

b. Threaded Type: ASTM D2464, Schedule 80.

2.1.4.3 Solvent Cement

ASTM D2564.

2.1.5 Polyethylene (PE) Plastic Piping

2.1.5.1 Pipe

AWWA C901, outside diameter (od) base with dimension ratio (DR) of 9.3 to provide 1034 kPa (150 psi) minimum pressure rating.

2.1.5.2 Fittings

ASTM D3261, DR of 9.3.

2.1.6 Dielectric Fittings

ASTM F441/F441M, Schedule 80, CPVC threaded pipe nipples, 100 mm (4 inch) length.

2.1.7 Drip Irrigation Tubing

ASTM D2287, maximum inside diameter (id) as indicated on contract drawings, vinyl plastic extruded from non-rigid chloride, integrally algae-resistant, homogeneous throughout, smooth inside and outside, free from foreign materials, cracks, serrations, blisters and other effects. Provide compression fittings.

2.1.8 Pipe Sleeving

a. Provide PVC piping two times the diameter of main or lateral piping.

b. Provide gray PVC electrical conduit sized according to number of control wires. Minimum 50 mm (2 inch) size.

2.2 IRRIGATION AND DRIP SPRINKLER HEADS

2.2.1 Fixed Riser Irrigation Heads

2.2.1.1 Stream Rotors, Full or Part Circle

Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Heavy duty, stainless steel internal construction with plastic body. Provide check valve below each sprinkler body on riser.

2.2.1.2 Gear Rotor Irrigation Head, Full or Part Circle

Single-stream, water lubricated, gear drive type capable of covering radius with distribution rate as indicated on contract drawings. Part circle sprinkler with an adjustable arc coverage of 0.52 to 6.28 rad (30 to 360 degrees). Stainless steel internal construction with plastic body, with matched precipitation rate nozzles in standard /low/ flat angle trajectories, filter screen, reducible watering radius, and choice of three nozzles.

2.2.1.3 Impact Irrigation Head

V pop-up capable of covering radius at pressure with distribution rate as indicated on contract drawings. Provide one or two nozzles to distribute water, an inlet strainer to prevent debris from clogging nozzles, and non-corrosive brass head and stainless steel assemblies. Seal bearing assembly from abrasives. Provide entire assembly including strainer removable from top of case without disturbing case installation. Provide plastic housing.

2.2.1.4 Spray Irrigation Heads, Full or Part Circle

Capable of covering radius at pressure and with discharge rate as indicated on contract drawings. Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Matched precipitation rate plastic nozzle with an adjustable screw capable of regulating the radius and the flow. Capable of housing under the nozzle; protective, non-clogging filter screen and/or pressure compensating devices. Screen used in conjunction with the adjusting screw from regulating. Provide check valve below each sprinkler body on riser.

2.2.1.5 Adjustable Flood Bubbler Head

Capable of providing a discharge rate at pressure as indicated on contract drawings, operating over a pressure range of 69 to 414 kPa (10 to 60 psi). Constructed of durable ultra-violet resistant plastic with a plastic inlet filter screen to protect the nozzle against clogging, and a stainless steel adjustable screw, capable of shutting off the bubbler and regulating the flow.

2.2.1.6 Pressure Compensating Flood Bubbler Head

Capable of providing a consistent discharge rate at pressure indicated on contract drawings. Plastic inlet filter screen bubbler assembly to protect the nozzle against clogging. Permanently assembled design constructed of durable, ultra-violet resistant plastic with an integral rubber flow washer for regulating the discharge rate at an operating pressure range of 138 to 621 kPa (20 to 90 psi).

2.2.2 Pop-Up Irrigation Head

2.2.2.1 Stream Rotor Irrigation Head, Full or Part Circle

Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Heavy duty, stainless steel internal construction with plastic body. Pop-up height of 75 mm (3 inches) as measured from top of cap at normal installation to middle of nozzle orifice, unless otherwise indicated on contract drawings. Provide check valve in head.

2.2.2.2 Gear Rotor Irrigation Head, Full or Part Circle

Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic. Heavy duty, stainless steel internal construction with plastic body and match precipitation rates for standard low or flat angle trajectories. Single-stream, water lubricated, gear drive type capable of covering radius at pressure and with distribution rate indicated on contract drawings. Part circle sprinkler with adjustable arc coverage of 0.52 to 6.28 rad (30 to 360 degrees). Pop-up height of 75 mm (3 inches) as measured from top of cap at normal installation to middle of nozzle orifice, unless otherwise indicated on contract drawings. Provide wiper seal that positively seals against nozzle flange to keep debris out of rotor and cleans debris from pop-up steam as it retracts. Provide check valve in head.

2.2.2.3 Impact Irrigation Head

Capable of covering radius at pressure and with distribution rate indicated on contract drawings. Provide one or two nozzles to distribute water, an inlet strainer to prevent debris from clogging nozzles, and non-corrosive brass head and stainless steel assemblies. Seal bearing assembly from abrasives. Provide entire assembly including strainer removable from top of case without disturbing case installation. Provide plastic housing. Pop-up height of 75 mm (3 inches) as measured from top of cap at normal installation to middle of nozzle orifice, unless otherwise indicated on contract drawings.

2.2.2.4 Spray Irrigation Head, Full or Part Circle

Capable of covering at pressure and with distribution rate indicated on contract drawings. Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic with wiper seal. Brass nozzle with matched precipitation rate and an adjustable screw capable of regulating the radius and flow. Capable of housing under the nozzle; protective, non-clogging filter screen and/or pressure compensating devices. Screen used in conjunction with the adjusting screw from regulating. Pop-up height of 75 mm (3 inches) as measured from the top of cap at normal installation to middle of nozzle orifice, unless otherwise indicated on contract drawings. Provide check valve below each sprinkler body on riser.

2.2.3 Bubbler Irrigation Head

2.2.3.1 Adjustable Flood Bubbler

Capable of providing a discharge rate at pressure indicated on contract drawings, operating over a pressure range of 69 to 414 kPa (10 to 60 psi). Construct of durable ultra-violet resistant plastic with a plastic inlet filter screen to protect the nozzle against clogging, and a stainless steel adjusting screw, capable of shutting off the bubbler and regulating the flow. Pop-up height of 75 mm (3 inches) as measured from top of cap at normal installation to middle of nozzle orifice, unless otherwise indicated on contract drawings.

2.2.3.2 Pressure Compensating Flood Bubbler

Capable of providing a consistent discharge rate at pressure indicated on contract drawings. Plastic inlet filter screen bubbler assembly to protect the nozzle against clogging. Permanently assembled design constructed of durable, ultra-violet resistant plastic with an integral rubber flow washer for regulating the discharge rate at an operating pressure range of 138 to 621 kPa (20 to 90 psi). Pop-up height of 75 mm (3 inches) as measured from top of cap at normal installation to middle of nozzle orifice, unless otherwise indicated on contract drawings.

2.2.4 Fixed Drip Head

2.2.4.1 Multi-Port Outlet Device

Multi-outlet, pressure compensating emitter manifold that is ultra-violet resistant, algae, and heat resistant, non-corrosive PVC material for above or below grade installation. Integral 75 micrometers (200 mesh) fabric screen that can be serviced from the top of the unit by unscrewing the top cap. Twelve, top or bottom mounted outlet ports that will accept 6 mm (1/4 inch) vinyl tubing, unless otherwise indicated on contract drawings. The twelve ports shall be accessed through the top of the unit by unscrewing the lid from the base. Each outlet port accepts a pressure compensating emitter controlling the flow from 1.89 to 90.84 (0.5 to 24.0 gph) per outlet. Operating range of unit is 103 to 345 kPa with 13 mm (15 to 50 psi with 1/2 inch) female national pipe thread (FNPT) inlet.

Multi-outlet, pressure-compensating emitter constructed of a ultra-violet resistant algae and heat resistant, non-corrosive PVC material. Diaphragm/flap constructed of a silicone elastomer material. Pressure-compensated emitter with each outlet delivering a nominal flow of 3.79 L/h (1.0 gph) at 103 to 345 kPa (15 to 50 psi), unless otherwise indicated on contract drawings. Six barbed outlet unit that will accept 6 mm (1/4 inch) vinyl tubing with continuous "self flushing" emitter feature, unless otherwise indicated on contract drawings.

2.2.4.2 Single Outlet Pressure Compensating Emission Device

Pressure compensated emitter body constructed of ultra-violet, algae, heat resistant and chemical resistant, non-corrosive PVC material. Diaphragm constructed of a silicone elastomer material. Capable of delivering a nominal flow rate of 3.79 L/h (1.0 gph) at a pressure range of 103 to 345 kPa (15 to 50 psi), unless otherwise indicated on contract drawings. A self piercing inlet barb type 13 mm (1/2 inch) female national pipe thread (FNPT) inlet mounted onto a 13 mm (1/2 inch) male national pipe thread (MNPT) riser. Barbed emitter outlet configuration that will accept 6 mm (1/4 inch) vinyl tubing.

2.2.4.3 Microspray Device

Capable of covering 0 to 4500 mm (0 to 15feet) radius at pressure and with discharge rate and overall pop-up height as indicated on contract drawings. Sprinkler body, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic with wiper seal on sprinkler. Matched precipitation rate brass or plastic nozzle with an adjustable screw capable of regulating the radius and flow and capable of housing under the nozzle; protective, non-clogging filter screens and/or pressure compensating devices. Screen used in conjunction with the adjusting screw for regulating. Mount with 13 mm (1/2 inch) female national pipe thread (FNPT) adapter.

2.2.4.4 In-Line Tubing Device

Factory installed, heavy-walled flexible polyethylene (PE) tubing, pressure compensating, self-cleaning emitters at spacings of 450 mm (18 inches), unless otherwise indicated on contract drawings. Emitter flow of 3.79 L/h (1.0 gph) with inlet pressure of as indicated on contract drawings. Tubing diameter of 13 mm (1/2 inch).

2.2.5 Pop-Up Drip Head

Capable of covering 0 to 4500 mm (0 to 15 feet) radius at pressure and with discharge rate as indicated on contract drawings with overall pop-up height of 100 mm (4 inches). Sprinkler body, steam, nozzle, and screen constructed of heavy-duty, ultra-violet resistant plastic with wiper seal on sprinkler. Provide a heavy-duty, stainless steel retract spring for positive pop-down and a ratcheting system for easy alignment of the pattern. Matched precipitation rate brass nozzle with an adjusting screw capable of regulating the radius and flow and capable housing under the nozzle; protective, non-clogging filter screens and/or pressure compensating devices. Screen used in conjunction with the adjusting screw for regulating. A side and bottom 12.70 mm (1/2 inch) female national pipe thread (FNPT) inlet for the 150 mm (6 inch) model. Mount with 12.70 mm (1/2 inch) female national pipe thread (FNPT) adapter poly flex riser stake.

2.3 VALVES

Provide lavender-colored assembly for non-potable use.

2.3.1 Isolation Valve

2.3.1.1 Ball Valves, Less than 75 mm (3 inches)

API Std 598, brass body, threaded ends.

2.3.1.2 Gate Valves, 75 mm (3 inches) and Larger

AWWA C500, bottom wedging double discs, parallel seats, non-rising stems, open by counterclockwise turning. Provide flanged end connections. Provide bronze interior construction of valves including stem containing a maximum 2 percent aluminum and maximum 16 percent zinc.

2.3.2 Control Valves

2.3.2.1 Pressure Regulating Master Control Valve

Automatic mechanical self-cleaning, self-purging control system having an adjustable pressure setting operated by a solenoid with voltage and current as indicated on contract drawings Valve shall close slowly and be free of chatter in each diaphragm position. Provide a manual flow stem to adjust closing speed and internal flushing. Provide an adjusting screw for setting pressure and Schrader valve for monitoring pressure. Provide one inlet taps capable of being installed as a straight pattern valve. Provide heavy duty cast iron valve body with brass seat that is removable and serviceable from top without removing valve body from system. Maximum working pressure of valve is 1034 kPa (150 psi) and pilot range from 69 to 862 kPa (10 to 125 psi).

2.3.2.2 Remote Control Valve, Electrical

Solenoid actuated globe valves of 20 to 75 mm (3/4 to 3 inch) size, in-rush and holding current and voltage as indicated on contract drawings. Provide brass valve housing suitable for service at 1034 kPa (150 psi) operating pressure. Provide pressure regulating module capable of regulating outlet pressure between 103 to 172 kPa (15 to 25 psi) (plus or minus) 34 kPa (5 psi) and adjustable screw for setting pressure Schrader valve connection for monitoring pressure.

2.3.2.3 Manual Angle Control Valve, Manual Globe Control Valve

Less than 65 mm (2 1/2 inch) MSS SP-80, type 3, Class 150 threaded ends. Angle valve 65 mm (2 1/2 inch) and larger MSS SP-85, Type II, Class 250 threaded ends.

2.3.3 Quick Coupling Valves

Two piece unit consisting of a coupler water seal valve assembly and a removable upper body to allow spring and key track to be serviced without shutout of main. Provide brass parts. Provide yellow or lavender lockable lids with springs for positive closure on key removal.

2.3.4 Hose Bib

One piece consisting of all brass construction with full flow 13 mm (1/2 inch) hose connection outlet and with attached handle with gaskets and washers.

2.3.5 Drain Valves

2.3.5.1 Manual

MSS SP-80, Type 3, Class 150 threaded ends for sizes less than 65 mm (2 1/2 inches). MSS SP-85, Type II, Class 250 threaded ends for sizes 65 mm

(2 1/2 inches) and larger.

2.3.5.2 Automatic

Brass, spring loaded ball drip type, 1034 kPa (150 pounds) and threaded ends, designed to close at 1.83 m (6 foot) pressure head with positive seal at 21 kPa (3 psi) pressure or greater and be open to drain at less than 21 kPa (3 psi) pressure.

2.3.6 Backflow Preventers

2.3.6.1 Reduced Pressure Type Backflow Preventers

AWWA C511. Provide backflow preventers complete with 1034 kPa (150 psi) rated flanged cast iron, bronze, or brass mounted gate or ball valve and strainer, 304 stainless steel or bronze, internal parts. Total pressure drop through complete assembly shall be a maximum of 69 kPa (10 psi) at rated flow. Listing of particular make, model/design, and size in FCCCHR List will be acceptable as required proof for testing and certification.

a. Piping Assembly: Red brass or galvanized steel pipe and fittings.

b. Strainers: Bronze or brass construction with gasket caps. Equip units with 75 micrometers (No. 200 mesh) stainless steel screen elements.

2.3.6.2 Pressure Type Vacuum Breaker

ASSE 1020 bronze or brass construction, with one or two check valves, vacuum relief, inlet and discharge shut-offs valves, and field test cocks, and with vacuum relief opening of greater diameter than unit.

2.3.6.3 Atmospheric Vacuum Breaker

AWWA M14, vacuum relief, inlet and discharge openings, and with vacuum relief opening of greater diameter than unit.

2.4 ACCESSORIES AND APPURTENANCES

2.4.1 Tapping Tee

Bronze flat, double strap, with neoprene gasket or "O"-ring seal.

2.4.2 Water Meter

Meter to include roll sealed register, magnetic drive, straight reading (odometer shall indicate in liters (gallons), large numerals, glass lens for legibility,) low flow indicator to detect leaks, tamper proof seal pin to detect theft; sturdy durable, corrosion resistant main case, electrical grounding continuity; nutating disc measuring chamber with minimum head loss.

2.4.3 Drip Head Accessories

2.4.3.1 Strainer

Provide strainer at inlet to each drip control valve assembly. Provide polyester fabric screen attached to a PVC frame having the equivalent of

56 micrometers (150 mesh) filtration capacity. Compact "Y" body and cap configuration. Incorporate flush valves within strainer to clean screen without disassembling unit.

2.4.3.2 Riser Adapters

PVC material, threaded to attached drip heads to tubing, pop-up irrigation body, or rigid piping and tubing to rigid piping.

2.4.3.3 Tubing Stakes

Plastic, plastic coated steel, or other non-corrosive strong material to secure tubing.

2.4.3.4 Bug Cap

Provide check valves at end of each emitter outlet distribution line. Valves shall permit free flow of water with minimum restriction; prevent back siphoning, entry of insects, and contamination into outlet ports.

2.4.3.5 Subterranean Drip Box and Cover

Construct of ultra-violet resistant PVC. Two slots in bottom of box to allow for installation of distribution tubing onto the emission device.

2.4.3.6 Line Flushing Valve

Construct of PVC with maximum flow rate of 0.95 L/s (15 gpm) with minimum flushing water volume of 3.79 liters (one gallon) at a minimum 28 kPa (4 psi) to a maximum 172 kPa (25 psi) at a point of discharge.

2.4.3.7 Valve Boxes

Cast-iron, precast concrete manufactured in accordance with Section 03 40 00.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION, or plastic valve box for each isolation valve, control valve, quick coupling valve, and drain valve. Provide box sizes that are suitable and adjustable for valve used.

a. Cast the word "IRRIGATION" on cover.

b. Stencil, engrave, or brand controller and valve sequence on remote control valve cover. Letters minimum 10 mm (4 inches) height.

2.4.4 Backflow Preventer Accessories

2.4.4.1 Pressure Gages

ASME B40.100, single style pressure gage for water with 113 mm (4 1/2 inch) dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and siphon. Provide scale range suitable for irrigation systems.

2.4.4.2 Water Hammer Arresters

ASSE 1010; stainless steel construction with an encased and sealed bellows compression chamber.

2.4.4.3 Backflow Preventer Enclosure

Frame to be constructed of 4.76 mm (3/16 inch) stainless steel angle iron with 38.10 mm (1 1/2 inch) No. 9 expanded metal covering. Construct in a one piece single swing hinge configuration. Provisions for pad locking and lighting handles. Size to fit backflow assembly to installed. Color to be green. Lock for enclosure provided by others.

2.4.4.4 Concrete Pads

Cast-in-place reinforced concrete construction for reduced pressure type backflow preventers.

2.4.5 Moisture Sensing Device

2.4.5.1 Automatic Rain Shut-Off Device

One piece, maintenance and adjustment free, reacts to a minimum 3.18 mm (1/8 inch) of rain water, unaffected by humidity levels, commercial grade materials, no exposed mechanical switch or electrodes, solid state construction with internal relay operating voltage of 24 to 30 VAC, static charge pretested, maximum switch current of one amp.

2.4.5.2 Automatic Freeze Shut-Off Device

Construct of a PVC cylinder with a sensing element mounted at top of cylinder capable of interrupting the control valve common wire as temperatures approach 0 degrees C (32 degrees F). Operating voltage 24 VAC, maximum current one amp. Static charge protection with snubber network.

2.4.5.3 Soil Moisture Sensor Device

24 VAC, field adjustable and capable of interrupting irrigation cycles for pre-determined moisture level at moisture probe location. Waterproof field adjustment module with bypass switch.

2.4.6 Air/Vacuum Relief

Construct of PVC with a maximum operating pressure of 965 kPa (140 psi).

2.4.7 Water Booster Package

Booster pump package to be a prefabricated system, pre-piped, pre-wired and mounted on a steel skid base minimum 75 mm (3 inch) welded angle iron or channel brackets, hot dipped galvanized, with a minimum 14 mm (9/16 inch) holes at each corner for bolting to concrete with anchors. Field assembled pump systems are not acceptable.

2.4.7.1 Pump

Pump to be end suction close coupled or in-line type, bronze impeller and wear rings, bronze shaft sleeve, mechanical seal with high-resist seat, integral flanged suction and discharge connections, keyed motor shaft, back pull-out type, with centerline discharge for automatic venting and Type 304 stainless steel internal parts and fittings.

2.4.7.2 Motor

Motor with rpm, horsepower, and one or three phases as indicated on contract drawings, ball bearing design, stainless steel shaft, non-over loading on full range of the impeller curve without use of the service factor and including rodent and insect screens over the openings. Single phase motors to be totally enclosed fan cooled and open drip-proof with a minimum 1.15 service factor. Three phase motors to be totally enclosed fan cooled, open drip-proof with a minimum 1.15 service factor.

2.4.7.3 Piping and Fittings

Piping and fittings to be flanged spools of Schedule 40 steel and Class 150 weld flanges, hot dipped galvanized after fabrication. Spacer spools to be welded and galvanized. Companion flanges at suction and discharge header connections to be Schedule 40 steel and galvanized.

2.4.7.4 Gages

Gages shall be 65 mm (2 1/2 inch) diameter, liquid filled for vibration dampering, 0-200 pounds, stainless steel casing, with brass needle valve shut-off cocks.

2.4.7.5 Butterfly Valve

Butterfly valves and adjustable handles to be sandblasted and epoxy coated, nuts and bolts to be cad plated, shut off valves to be centerline butterfly lug type, wafer style, drilled and tapped, with bronze disc, capable of remaining installed in the piping.

2.4.7.6 Check Valves

A combination pressure reducing and non-slam check valve to be installed with booster pump package to reduce effect of varying suction pressure.

2.4.7.7 Pump Control Panels

Pump control panels to be 14 gage type UF, type 304 stainless steel with continuous welded seams, door with continuous hinge, all welds passivated to eliminate corrosion, UL listed, NEMA 3R enclosure with holes in bottom to allow for all inlet wiring for main power control accessories and louvers with insect screens on opposite sides for cross ventilation, deadfront, keylockable and padlockable, with main disconnect switch, circuit breaker with adjustable overloads on all legs and adjustable inrush current trip setting on units exceeding 41 amps, heavy duty contactor, 115 volt control circuit transformer with circuit breaker disconnect. A plug-in module type pump start relay shall be mounted and hard wired in the pump panel. A electronic flow switch with 0-60 seconds adjustable time delay relay, mounted and hard wired in the pump panel, to operate as a no-flow safety shut down. NEMA 3R non-fused main disconnect switch, mounted on exterior of pump panel, hard wired to panel circuit breaker.

2.4.8 Flow Meter

25.40 mm (one inch) flow meter with a minimum flow rate as indicated, female national pipe threaded ends and replaceable metering insert, unless otherwise indicated on contract drawings. 9 volt direct current output with a pulse rate which is proportional to the L/s (gpm), a 0.067 amperes fuse link to protect metering insert and 14 gage output feeder wire to be powered by the controller. Provide brass meter housing suitable for service at 1034 kPa (150 psi) operating pressure.

2.5 Automatic Controller Electricalor Battery

Controller, NEMA ICS 2 with 120-volt single phase service or 24 VDC battery, as indicated, operating with indicated station and grounded chassis. Provide enclosure NEMA ICS 6 Type 3R, with locking hinge cover, wall mounted pedestal mounted.

2.5.1 Controller Features

a. Multi-station controller with number of independent programs and stations that can run concurrently as indicated on contract drawings.

b. Allows an infinite number of cycles per day by placing the program in a looping mode.

c. Ability to be programmed in one second increments, from one second to 24 minutes.

d. A water budgeting capability in all stations within a program in one percent increments from one percent to 255 percent.

e. A programmable watering calendar ranging from one to 16 days.

f. A single-station timed manual feature that allows a station to be turned on manually for its programmed watering time.

g. A semi-automatic manual cycle feature.

h. True manual operation with safety shut-off at midnight and visible indication of which station is on.

i. UL listed, having a re-settable circuit breaker, cadmium plated, weatherproof steel case, and keyed lock.

j. Evapotranspiration controller with no service fees.

2.6 ELECTRICAL CIRCUITS

2.6.1 Control Wiring for Electrically Operated Valves

NFPA 70, copper conductor 1.8 mm (14 gage) wire, Type UF.

2.6.2 Conduit

UL 651, rigid polyvinyl chloride conduit, Schedule 40.

2.7 CONCRETE MATERIALS

20 MPa (2500 psi) compressive concrete strength at 28 days as specified under Section 03 30 00 CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 INSTALLATION

Install sprinkler system after site grading has been completed.

3.1.1 Trenching

Hand trench around roots to pipe grade when roots of 50 mm (2 inches) diameter or greater are encountered. Make width of trench 100 mm (4 inches) minimum or 1 1/2 times diameter of pipe, whichever is wider. Backfill and hand tamp over excavation. When rock is encountered, excavate 100 mm (4 inches) deeper and backfill with silty sand (SM) or well-graded sand (SW) to pipe grade. Keep trenches free of obstructions and debris that would damage pipe. Do not mix subsoil with topsoil. Bore under existing concrete walks, drives and other obstacles at a depth conforming to bottom of adjacent trenches. Install pipe sleeve, two pipe diameters larger than sprinkler pipe, to fill bore. Rock will be encountered. Excavate 100 mm (4 inches) deeper and backfill with silty sand (SM) or well graded sand (SW) to pipe grade. Prior to backfilling of trench, Contracting Officer shall verify and approve location of all irrigation heads.

3.1.2 Piping System

3.1.2.1 Clearances

a. Minimum horizontal clearances between lines: 100 mm for 50 mm (4 inches for 2 inch) pipe and less; 300 mm for 50 mm (12 inches for 2 inch) pipe and more.

b. Minimum vertical clearances between lines: 25 mm (one inch).

3.1.2.2 Minimum Pitch

Down 150 mm per 30 m (6 inches per 100 feet) in direction of drain valves.

3.1.2.3 Thrust Blocks

Install thrust blocks at bends, tees, plugs and valves or 63 mm (2 1/2 inches) and larger mainline piping. Place concrete so that sides subject to thrust or load are against undisturbed earth, and valves and fittings are serviceable after concrete has set.

3.1.2.4 Minimum Backfill Cover

a. 450 mm (18 inches) for pressure mainline pipe and valve control wire.

b. 300 mm (12 inches) for non-pressure lateral pipe.

c. 600 mm (24 inches) for all piping under paved or non-paved pedestrian paths.

d. 900 mm (36 inches) for all piping under traffic loads, farm operations, freezing temperatures.

e. Install pipe sleeves at depths indicated in "c" and "d".

Rock will be encountered. Provide minimum 100 mm (4 inches) of silty sand (SM) or well graded sand (SW) cover on top of all piping. Fill remainder of trench or pipe cover to within 75 mm (3 inches) of top with excavated soil, and compact soil with plate hand-held compactors to same density as undisturbed adjacent soil.

3.1.2.5 Restoration

Fill top 75 mm (3 inches) with topsoil and compact with same density as surrounding soil. Restore turf and plants according to Section 32 92 19 SEEDING, Section 32 92 23 SODDING, Section 32 93 00 EXTERIOR PLANTS.

3.1.2.6 Sterilization

Sprinkler system fed from a potable water system sterilized upstream of backflow preventer in accordance with AWWA C651. Sterilize new water lines for a minimum of 24 hours to meet local health test requirements before placing in service. Minimum retention period shall be 3 hours.

3.1.3 Piping Installation

3.1.3.1 Polyvinyl Chloride (PVC) Pipe

a. Solvent-Cemented Joints: ASTM D2855.

b. Threaded Joints: full cut with a maximum of three threads remain exposed on pipe and nipples. Make threaded joints tight without recourse to wicks or fillers, other than polytetrafluoroethylene thread tape.

c. Piping: ASTM D2774 or ASTM D2855, and pipe manufacturer's instructions. Install pipe in a serpentine (snaked) manner to allow for expansion and contraction in trench before backfilling. Install pipes at temperatures over 4.5 degrees C (40 degrees F).

3.1.3.2 Soldered Copper Tubing

Ream pipe and remove burrs. Clean and polish contact surfaces of joint. Flux both male and female ends. Insert end of tube into fittings full depth of socket. After soldering, a solder bead shall show continuously around entire joint circumference. Remove excess acid flux from tubing and fittings.

3.1.3.3 Threaded Brass or Galvanized Steel Pipe

Prior to installation ream pipe. Cut threads as specified in ASME B1.2. Make joints with pipe joint compound applied to male end only.

3.1.3.4 Polyethylene (PE) Pipe and Drip Tubing

Bury drip tubing and PE pipe 300 mm (12 inches) deep. Compression connection in accordance with manufacturer's recommendation. Install hose in serpentine manner. When cutting hose, use a shearing tool such as a pipe cutter, knife or shears. Use only manufacturer's recommended tool and procedure when installing drip heads.

3.1.3.5 Dielectric Protection

Where pipes of dissimilar metal are joined, make connection with dielectric fitting.

3.1.4 Irrigation Heads

Install plumb and level with terrain.

3.1.4.1 Fixed Riser Irrigation Heads

Nozzle mounted on fixed riser minimum 150 mm (6 inches) above grade in mulched planter beds, 300 mm (12 inches) above grade in planter beds with groundcover. Provide swing joint assembly attachment between lateral lines and fixed risers.

3.1.4.2 Pop-Up Irrigation Head

Install plumb and level with terrain. Provide swing joint assembly attachment between lateral line and pop-up body. Top of irrigation head shall be flush with surrounding finish grade. In recreational fields, install all pop-up rotors with stainless steel risers 125 mm (5 inches) below finish grade per manufacturer's recommendations.

3.1.4.3 Drip Heads

Install drip heads in plastic drip box. Connect drip head to a rigid PVC nipple. Attach tubing to barbed fitting and daylight distribution tubing at root ball secured with stake. Add bug cap at end of secured distribution tubing. After installing drip heads and before operating system, open end of drop lateral and flush lines clean. The number of drip heads on a line shall not exceed manufacturer's recommendations for that hose or distribution tubing size and length.

3.1.5 Valves

3.1.5.1 Isolation Valves

Install in a valve box extending from grade to below valve body, with a minimum of 100 mm (4 inches) cover measured from finish grade to top of valve stem.

3.1.5.2 Control Valves

Plumb valve in a valve box extending from grade to below valve body, with minimum of 100 mm (4 inch) cover measured from grade to top of valve. Install automatic valves beside sprinkler heads with a valve box.

3.1.5.3 Quick Coupling Valves

Install in a valve box extending from grade to below valve body, with a minimum of 100 mm (4 inches) cover measured from finish grade to top of valve stem. Install 50 mm (2 inches) above finish grade in planter bed, level with finish grade in turf areas.

3.1.5.4 Hose Bibb

Install below grade in valve box with support, unless otherwise indicated on contract drawings.

3.1.5.5 Drain Valves

Entire system shall be manually or automatically drainable. Equip low point of each underground line with drain valve draining into an excavation containing gravel. Cover gravel with building paper. Backfill with excavated material and 150 mm (6 inches) of topsoil.

3.1.6 Backflow Preventers

a. Install backflow preventer in new connection to existing water distribution system, between connection and control valves. Install with concrete pads. Install with concrete pads in turf only.

b. Flush pipe lines prior to installing device.

c. Device shall not be installed in pits or where any part of the device could become submerged in standing water

d. Install device a minimum of 300 mm (12 inches) from trees, walls, fences, structures and other obstructions.

3.1.6.1 Reduced Pressure Backflow Preventer

a. Protect device by a strainer located upstream.

b. Install device a minimum of 300 mm (12 inches) between finish grade and bottom of relief port.

c. Where freezing conditions occur, locate device inside a building and pipe the relief valve port through an air gap to a drain.

d. Install water meter above grade, upstream of unit of unit as a part of assembly. Provide galvanized steel support with concrete footing.

3.1.6.2 Pressure Vacuum Breaker

a. Install device a minimum of 300 mm (12 inches) between highest irrigation head and bottom of air relief valve.

b. Where freezing conditions occur, locate device inside a building and pipe the relief valve port through an air gap to a drain.

3.1.6.3 Atmospheric Vacuum Breaker

Install device minimum of 300 mm (12 inches) between highest irrigation head and bottom of relief valve located downstream of irrigation control valve.

3.1.7 Accessories

3.1.7.1 Connection To Existing Water Supply Systems (Tapping Tee)

Use tapping or drilling machine valve and mechanical joint type sleeves for connections to be made under pressure. Bolt sleeves around mains; bolt valve conforming to AWWA C500 to the branch. Open valve, attach drilling machine, make tap, close valve, and remove drilling machine, without interruption of service. Notify Contracting Officer in writing at least 15 days prior to the date the connections are required; receive approval before any service is interrupted. Provide materials required to make connections into the existing water supply systems and perform excavating, backfilling, and other incidental labor as required. Furnish the labor and the tapping or drilling machine for making the actual connections to the existing systems.

3.1.7.2 Water Meter

Install meter upstream of backflow preventer per manufacturer's recommendations and local DPW Utilities Branchinstructions. Plumb meter in a valve box extending from grade to below meter body, with a minimum of 100 mm (4 inch) cover measured from top of grade to top of meter.

3.1.7.3 Valve Boxes and Lids

a. Install with 0.0283 cubic meters (one cu ft) pea gravel sump below valve.

b. Support valve box with brick.

c. Provide wire screen between gravel sump and bottom of valve body for rodent protection.

d. For turf areas, install flush with finish grade.

e. For planter beds, install 50 mm (2 inches) above finish grade.

f. For sloped conditions, install valve box level with terrain.

3.1.7.4 Backflow Preventer Enclosure

a. Install with concrete pad.

b. Place hinges so direction of swing will not conflict with other site features.

3.1.7.5 Rain and Freeze Shut-Off Devices

a. Install as per manufacturer's recommendations.

b. For wall mounted controllers, attach devices to side of building or eave, minimum 2400 mm (8 feet) above finish grade and a minimum of 300 mm (12 inches) from building wall or eave.

c. For pedestal mounted controllers, mount to side of controller housing on top of minimum 1050 mm (42 inches) high pole outside of irrigation coverage in vandal-resistant enclosure.

3.1.7.6 Soil Moisture Sensing Device

a. Bury the device at depth per manufacturer's recommendation in the effective root zone of hydrozone to be monitored.

b. Place a sensor-protection valve box with cover above the device, unless otherwise indicated on contract drawings.

c. Provide waterproof connection to all field splices in valve boxes.

3.1.7.7 Air/Vacuum Relief Valve

Locate at highest point in piping system.

3.1.8 Electrical Circuits

Bury wires beside mainline pipe in same trench. Provide gray electrical conduit where wires run under paved or non-paved pedestrian paths and vehicular roads. Tag wires at controller and control valve location with plastic tie wrapped tags. Provide one control wire to each control valve location and one common wire looped from controller to each control valve. provide one separate control valve wire of a different color from controller to each control valve cluster.

3.1.8.1 Loops

Provide a 300 mm (12 inch) loop of wire at each valve where controls are connected.

3.1.8.2 Expansion and Contraction

Bundle multiple tubes or wires and tape together at 3 m (10 foot) intervals with 300 mm (12 inch) loop for expansion and contraction.

3.1.8.3 Splices

Make electrical splices waterproof. Locate all field electrical splices in valve boxes.

3.1.9 Automatic Controller

Determine exact location of controllers in field before installation. Coordinate the electrical service to these locations. Install in accordance with manufacturer's recommendations and NFPA 70.

3.1.10 Flushing

After piping, risers, and valves are in place and connected, but prior to installation of sprinkler heads and valves, flush piping system under a full head of water. Maintain flushing for 3 minutes.

3.1.11 Adjustment

After grading, plant installation, and rolling of planted areas, adjust sprinkler heads flush with finished grade. Make adjustments by providing new nipples of proper length or by use of heads having an approved device, integral with head, which will permit adjustment in height of head without changing piping.

3.1.12 Sterilization

Sprinkler system fed from a potable water system shall be sterilized upstream of backflow preventer in accordance with AWWA C651. Sterilize new waterlines for a minimum of 24-hours, to meet local health test requirements before placing in service. Minimum retention period shall be 3 hours.

3.2 FIELD QUALITY CONTROL

The Contractor will conduct and the Contracting Officer and the QC representative will witness field inspections and field tests specified in this section. Perform field tests, and provide labor, equipment, and incidentals required for testing.

3.2.1 Pressure Test

3.2.1.1 Duration

During pressure test, maintain a hydrostatic pressure of 1034 kPa (150 psi) without pumping for a period of one hour with an allowable pressure drop of 35 kPa (5 psi) before backfilling system.

3.2.1.2 Leaks

Correct leaks. Make necessary corrections to stop leakage.

3.2.1.3 Retest

Retest system twice until pressure can be maintained for duration of test.

3.2.2 Operation Test

3.2.2.1 Accessories

At conclusion of pressure test, install irrigation heads or drip heads, quick coupling assemblies, and hose bib, and test entire system for operation under normal operating pressure. Make necessary corrections or adjustments to raise or lower pressure for each system if tests results do not match pressure requirements.

3.2.2.2 Acceptance

Operation test is acceptable if system operates through at least one complete cycle for areas to be irrigated.

3.2.3 Controller Charts

Provide one chart for each controller supplied. Indicate in chart area controlled by automatic controller. The chart is a reduction of the actual plans that will fit the maximum dimensions inside controller housing. Use black line print for chart and a different pastel or transparent color to indicate each station area of coverage. After chart is completed and approved for final acceptance, seal chart between two 0.5 mm (20 mil) pieces of clear plastic.

-- End of Section --

SECTION 32 92 19

SEEDING
10/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C602	(2007) Agricultural Liming Materials
ASTM D4427	(2007) Peat Samples by Laboratory Testing
ASTM D4972	(2001; R 2007) pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act	(1940; R 1988; R 1998) Federal Seed Act
DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, Section 32 96 00 TRANSPLANTING EXTERIOR PLANTS, Section 32 92 23 SODDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood cellulose fiber mulch

Seed

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-08 Manufacturer's Instructions

Erosion Control Materials

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Seed Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer, Gypsum, Sulfur, Iron, and, Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum, sulphur, iron, and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Seed, Fertilizer, Gypsum, Sulfur, Iron and Lime Storage

Store in cool, dry locations away from contaminants.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 32 degrees Celsius (90 degrees Fahrenheit).

1.7 TIME LIMITATIONS

1.7.1 Seed

Apply seed within twenty four hours after seed bed preparation.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Classification

Provide seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weed seed content, and inert material. Label in conformance with AMS Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2 Planting Dates

Planting Season	Planting Dates
Spring	April to May
Fall	August to September

2.1.3 Seed Purity

Weed seed shall not exceed 1 percent by weight of the total mixture.

2.1.4 Seed Mixture by Weight

Proportion seed mixtures by weight.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor, unless otherwise indicated on contract drawings .

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 19 mm (3/4 inch), with maximum 3 percent retained on 6 mm (1/4 inch) screen. The pH shall be tested in accordance with ASTM D4972. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	25-50 percent
Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427. Shred and granulate peat to pass a 12.5 mm (1/2 inch) mesh screen and condition in storage pile for minimum 6 months after excavation.

2.3.6 Sand

Clean and free of materials harmful to plants.

2.3.7 Perlite

Horticultural grade.

2.3.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.8.1 Particle Size

Minimum percent by weight passing:

4.75 mm (No. 4 mesh) screen	95
2.36 mm (No. 8 mesh) screen	80

2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 61 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 850 micrometers (20 mesh screen), 100 percent passing thru 970 micrometers (16 mesh) screen.

2.3.10 Calcined Clay

Calcined clay shall be granular particles produced from montmorillonite clay calcined to a minimum temperature of 650 degrees C (1200 degrees F). Gradation: A minimum 90 percent shall pass a 2.36 mm (No. 8) sieve; a minimum 99 percent shall be retained on a 0.250 mm (No. 60) sieve; and a maximum 2 percent shall pass a 0.150 mm (No. 100) sieve. Bulk density: A maximum 640 kilogram per cubic meter (40 pounds per cubic foot).

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic or synthetic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

5 percent available nitrogen
2 percent available phosphorus
1 percent available potassium

2.4.2 Hydroseeding Fertilizer

Controlled release fertilizer, to use with hydroseeding and composed of pills coated with plastic resin to provide a continuous release of nutrients for at least 6 months and containing the following minimum percentages, by weight, of plant food nutrients.

5 percent available nitrogen
2 percent available phosphorus
1 percent available potassium

2.5 MULCH

Mulch shall be free from noxious weeds, mold, and other deleterious materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw shall contain no fertile seed.

2.5.2 Hay

Air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Hay shall be sterile, containing no fertile seed.

2.5.3 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent) or wood-based (100 percent) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 5.5 to 8.2. Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

2.7 EROSION CONTROL MATERIALS

Erosion control material shall conform to the following:

2.7.1 Erosion Control Blanket

100 percent agricultural strawor 70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 12 months.

2.7.2 Erosion Control Fabric

Fabric shall be knitted construction of polypropylene yarn with uniform mesh openings 19 to 25 mm (3/4 to 1 inch) square with strips of biodegradable paper. Filler paper strips shall have a minimum life of 6 months.

2.7.3 Erosion Control Net

Net shall be heavy, twisted jute mesh, weighing approximately 605 grams per meter (1.22 pounds per linear yard) and 1200 mm (4 feet) wide with mesh openings of approximately 25 mm (1 inch) square.

2.7.4 Hydrophilic Colloids

Hydrophilic colloids shall be physiologically harmless to plant and animal life without phytotoxic agents. Colloids shall be naturally occurring, silicate powder based, and shall form a water insoluble membrane after curing. Colloids shall resist mold growth.

2.7.5 Erosion Control Material Anchors

Erosion control anchors shall be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation (including soil conditioners as required), fertilizing, seeding, and surface top dressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.1.1 Topsoil

Provide 102 mm (4 inches) of off-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer pH adjusters soil conditioners into soil a minimum depth of 100 mm (4 inches) by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 19 mm (3/4 inch) in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site. 3.1.1.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy frozen, snow covered or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method shall be broadcasted and drop seeding, drill seeding, or hydroseeding.

3.2.2.1 Broadcast and Drop Seeding

Seed shall be uniformly broadcast at the rate of 1.8 to 2.2kilograms per hectare (4 to 5 pounds per 1000 square feet). Use broadcast or drop seeders. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing. Cover seed uniformly to a maximum depth of 6 mm (1/4 inch) in clay soils and 13 mm (1/2 inch) in sandy soils by means of spike-tooth harrow, cultipacker, raking or other approved devices.

3.2.2.2 Drill Seeding

Seed shall be drilled at the rate of 1.8 to 2.2kilograms per hectare (4 to 5 pounds per 1000 square feet). Use cultipacker seeders or grass seed drills. Drill seed uniformly to average depth of 13 mm (1/2 inch).

3.2.2.3 Hydroseeding

First, mix water and fiber. Wood cellulose fiber, paper fiber, or recycled paper shall be applied as part of the hydroseeding operation. Fiber shall be added at 11.2 kg per 100 square meter (1,000 pounds, dry weight, per acre). Then add and mix seed and fertilizer to produce a homogeneous slurry. Seed shall be mixed to ensure broadcasting at the rate of 1.8 to 2.2kilograms per hectare (4 to 5 pounds per 1000 square feet). When hydraulically sprayed on the ground, material shall form a blotter like cover impregnated uniformly with grass seed. Spread with one application with no second application of mulch.

3.2.3 Mulching

3.2.3.1 Hay or Straw Mulch

Hay or straw mulch shall be spread uniformly at the rate of 0.75 metric tons per hectare (2 tons per acre). Mulch shall be spread by hand, blower-type mulch spreader, or other approved method. Mulching shall be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch shall not be bunched or clumped. Sunlight shall not be completely excluded from penetrating to the ground surface. All areas installed with seed shall be mulched on the same day as the seeding. Mulch shall be anchored immediately following spreading.

3.2.3.2 Mechanical Anchor

Mechanical anchor shall be a V-type-wheel land packer; a scalloped-disk land packer designed to force mulch into the soil surface; or other suitable equipment.

3.2.3.3 Asphalt Adhesive Tackifier

Asphalt adhesive tackifier shall be sprayed at a rate between 666 to 866 liters per hectare (10 to 13 gallons per 1000 square feet). Sunlight shall not be completely excluded from penetrating to the ground surface.

3.2.3.4 Non-Asphaltic Tackifier

Hydrophilic colloid shall be applied at the rate recommended by the manufacturer, using hydraulic equipment suitable for thoroughly mixing with water. A uniform mixture shall be applied over the area.

3.2.3.5 Asphalt Adhesive Coated Mulch

Hay or straw mulch may be spread simultaneously with asphalt adhesive applied at a rate between 666 to 866 liters per hectare (10 to 13 gallons per 1000 square feet), using power mulch equipment which shall be equipped with suitable asphalt pump and nozzle. The adhesive-coated mulch shall be applied evenly over the surface. Sunlight shall not be completely excluded from penetrating to the ground surface.

3.2.4 Rolling

Immediately after seeding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 134 kg per m (90 pounds) for each foot of roller width. If seeding is performed with cultipacker-type seeder or by hydroseeding, rolling may be eliminated.

3.2.5 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.6 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 50 mm (2 inches) without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 92 23

SODDING
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C602	(2007) Agricultural Liming Materials
ASTM D4427	(2007) Peat Samples by Laboratory Testing
ASTM D4972	(2001; R 2007) pH of Soils

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2103	(2003) Testing method for pH of soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS	(1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

100 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, Section 32 96 00 TRANSPLANTING EXTERIOR PLANTS, Section 32 92 19 SEEDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-07 Certificates

Nursery or Sod farm certification for sods. Indicate type of sod in accordance with TPI GSS.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Sod Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer, Gypsum, Sulfur, Iron, and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer ,gypsum, sulphur, iron and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Sod Storage

Lightly sprinkle with water, cover with moist burlap, straw, or other approved covering; and protect from exposure to wind and direct sunlight until planted. Provide covering that will allow air to circulate so that internal heat will not develop. Do not store sod longer than 24 hours. Do not store directly on concrete or bituminous surfaces.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 32 degrees Celsius (90 degrees Fahrenheit).

1.7 TIME LIMITATIONS

1.7.1 Sod

Place sod a maximum of thirty six hours after initial harvesting, in accordance with TPI GSS as modified herein.

PART 2 PRODUCTS

2.1 SODS

2.1.1 Classification

Nursery grown, certified as classified in the TPI GSS. Machine cut sod at a uniform thickness of 19 mm (3/4 inch) within a tolerance of 6 mm (1/4 inch), excluding top growth and thatch. Each individual sod piece shall be at least 150 mm by 150 mm (6 inches by 6 inches) and strong enough to support its own weight when lifted by the ends. Broken pads, irregularly shaped pieces, and torn or uneven ends will be rejected. Plug sod will not be permitted. Wood pegs and wire staples for anchorage shall be as recommended by sod supplier.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Planting Dates

Lay sod from April to June for warm season spring planting and from September to November for cool season fall planting.

2.1.4 Composition

2.1.4.1 Proportion

Grass species shall be proportioned as recommended by the supplier.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 19 mm (3/4 inch), with maximum 3 percent retained on 6 mm (1/4 inch) screen. The pH shall be tested in accordance with ASTM D4972 or KS F 2103. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	25-50 percent
Clay	10-30
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade hydrate or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 110 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427. Shred and granulate peat to pass a 12.5 mm (1/2 inch) mesh screen and condition in storage pile for minimum 6 months after excavation.

2.3.6 Sand

Clean and free of materials harmful to plants.

2.3.7 Perlite

Horticultural grade.

2.3.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.8.1 Particle Size

Minimum percent by weight passing:

4.75 mm (No. 4 mesh)	screen	95
2.36 mm (No. 8 mesh)	screen	80

2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 850 micrometers (20 mesh screen), 100 percent passing thru 970 micrometers (16 mesh) screen.

2.3.10 Calcined Clay

Calcined clay shall be granular particles produced from montmorillonite clay calcined to a minimum temperature of 650 degrees C (1200 degrees F). Gradation: A minimum 90 percent shall pass a 2.36 mm (No. 8) sieve; a minimum 99 percent shall be retained on a 0.250 mm (No. 60) sieve; and a maximum 2 percent shall pass a 0.150 mm (No. 100) sieve. Bulk density: A maximum 640 kilogram per cubic meter (40 pounds per cubic foot).

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic or synthetic, granular controlled release fertilizer.

5 percent available nitrogen
2 percent available phosphorus
1 percent available potassium

2.5 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation containing no element toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Extent Of Work

Provide soil preparation (including soil conditioners), fertilizing, and sodding of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.2 Soil Preparation

Provide 102 mm (4 inches) of off-site topsoil oron-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer, pH adjusters, or soil conditioners into soil a minimum depth of 100 mm (4 inches) by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 19 mm (3/4 inch) in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.2 SODDING

3.2.1 Finished Grade and Topsoil

Prior to the commencement of the sodding operation, the Contractor shall verify that finished grades are as indicated on drawings; the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 31 00 00 EARTHWORK.

The prepared surface shall be a maximum 25 mm (1 inch) below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove from the surface debris and stones over a minimum 16 mm (5/8 inch) in any dimension.

3.2.2 Placing

Place sod a maximum of 36 hours after initial harvesting, in accordance with TPI GSS as modified herein. Rows of sod sections shall be placed parallel to and tightly against each other. Joints shall be staggered laterally. The sod sections shall not be stretched or overlapped. Joints between adjacent sod piece shall be no more than 6 mm (1/4 inch). Voids and air drying of roots shall be prevented. Sod sections shall be laid across the slope on long slopes. Sod sections shall be laid at right angles to the flow of water in ditches. Anchoring may be required when surface weight or pressure upon placed sod sections is anticipated to cause lateral movement.

Initial sod placement shall be witnessed by the Contracting Officer Representative (COR), who will approve or disapprove the placement method. Contact COR at least one week prior to intended date of sod placement to arrange for inspection. Contractor shall not place sod until COR has witnessed and approved placement method.

3.2.3 Sodding Slopes and Ditches

For slopes 2:1 and greater, lay sod with long edge perpendicular to the contour. For V-ditches and flat bottomed ditches, lay sod with long edge perpendicular to flow of water. Anchor each piece of sod with wood pegs or wire staples maximum 600 mm (2 feet) on center. On slope areas, start sodding at bottom of the slope.

3.2.4 Finishing

After completing sodding, blend edges of sodded area smoothly into surrounding area. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed and holes and missing corners shall be patched with sod.

3.2.5 Rolling

Immediately after sodding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 134 kg per m (90 pounds) for each foot of roller width.

3.2.6 Watering

Start watering areas sodded as required by daily temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to minimum depth of 150 mm (6 inches). Run-off, puddling, and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be driven over turf areas. Watering of other adjacent areas or plant material shall be prevented.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 93 00

EXTERIOR PLANTS
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA P5	(2010) Standard for Waterborne Preservatives
AWPA T1	(2009) Use Category System: Processing and Treatment Standard
AWPA U1	(2014) Use Category System: User Specification for Treated Wood

AmericanHort (AH)

ANSI/ANLA Z60.1	(2004) American Standard for Nursery Stock

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2014) Standard Specification for Stainless Steel Wire
ASTM C602	(2007) Agricultural Liming Materials
ASTM D4427	(2007) Peat Samples by Laboratory Testing
ASTM D4972	(2001; R 2007) pH of Soils
ASTM D5268	(2007) Topsoil Used for Landscaping Purposes
ASTM D5539	(1994; R 2008) Seed Starter Mix

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3703	(2007) Stainless Steel Wires
KS F 2103	(2003) Testing method for pH of soils

L.H. BAILEY HORTORIUM (LHBH)

LHBH	(1976) Hortus Third

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA A300P1	(2008) ANSI A300 Part1: Tree Care Operations - Trees, Shrubs and Other Woody

	Plant Maintenance Standard Practices - Pruning
TCIA Z133.1	(2006) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, Section 32 96 00 TRANSPLANTING EXTERIOR PLANTS, Section 32 92 19 SEEDING, Section 32 92 23 SODDING, , and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Landscape Contractor's License

Time Restrictions and Planting Conditions

Indicate anticipated dates and locations for each type of planting.

SD-03 Product Data
Weed control fabric; G
Metal anchors

Erosion control materials

Photographs; G

Mulch

SD-06 Test Reports

Topsoil composition tests; Soil Test of current growing area; Soil Test of proposed area; Soil Test location map

Percolation Test; Percolation Test of current growing area; Percolation Test of proposed area

SD-07 Certificates

Nursery certifications

Indicate names of plants in accordance with the LHBH, including type, quality, and size.

1.4 QUALITY ASSURANCE

1.4.1 Topsoil Composition Tests

Commercial test from an independent testing laboratory including basic soil groups (moisture and saturation percentages, Nitrogen-Phosphorus-Potassium (N-P-K) ratio, pH (ASTM D4972 or KS F 2103), soil salinity), secondary nutrient groups (calcium, magnesium, sodium, Sodium Absorption Ratio (SAR)), micronutrients (zinc, manganese, iron, copper), toxic soil elements (boron, chloride, sulfate), cation exchange and base saturation percentages, and soil amendment and fertilizer recommendations with quantities for plant material being transplanted. Soil required for each test shall include a maximum depth of 450 mm (18 inches) of approximately 1 liter (1 quart) volume for each test. Areas sampled should not be larger than 0.4 hectare (1 acre) and should contain at least 6-8 cores for each sample area and be thoroughly mixed. Problem areas should be sampled separately and compared with samples taken from adjacent non-problem areas. The location of the sample areas should be noted and marked on a parcel or planting map for future reference.

1.4.2 Nursery Certifications

a. Indicate on nursery letterhead the name of plants in accordance with the LHBH, including botanical common names, quality, and size.

b. Inspection certificate.

c. Mycorrhizal fungi inoculum for plant material treated

1.4.3 Landscape Contractor's License

Construction company shall hold a landscape contractors license and have a minimum of five years landscape construction experience. Submit copy of license and three references for similar work completed in the last five years.

1.4.4 Plant Material Photographs

Contractor shall submit nursery photographs, for government approval prior to ordering, for each tree larger than 600 mm (24-inch) box/ 50 mm (2-inch) caliper size.

1.4.5 Percolation Test

Immediately following rough grading operation, identify a typical location for one of the largest trees and or shrubs and excavate a pit per the project details. Fill the pit with water to a depth of 300 mm (12 inches). The length of time required for the water to percolate into the soil, leaving the pit empty, shall be measured by the project Landscape Architect and verified by the Contracting Officer. Within six hours of the time the water has drained from the pit, the Contractor, with the Contracting Officer and project Landscape Architect present, shall again fill the pit with water to a depth of 300 mm (12 inches). If the water does not completely percolate into the soil within 9 hours, a determination shall be made whether a drainage system or a soil penetrant will be required for each tree and or shrub being transplanted.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Branched Plant Delivery

Deliver with branches tied and exposed branches covered with material which allows air circulation. Prevent damage to branches, trunks, root systems, and root balls and desiccation of leaves.

1.5.1.2 Soil Amendment Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to ROK national, provincial, and local laws. Instead of containers, fertilizer, gypsum, sulfur, iron, and lime may be furnished in bulk with a certificate indicating the above information. Store in dry locations away from contaminates.

1.5.1.3 Plant Labels

Deliver plants with durable waterproof labels in weather-resistant ink. Provide labels stating the correct botanical and common plant name and variety as applicable and size as specified in the list of required plants. Attach to plants, bundles, and containers of plants. Groups of plants may be labeled by tagging one plant. Labels shall be legible for a minimum of 60 days after delivery to the planting site.

1.5.2 Storage

1.5.2.1 Plant Storage and Protection

Store and protect plants not planted on the day of arrival at the site as follows:

a. Shade and protect plants in outside storage areas from the wind and direct sunlight until planted.

b. Heel-in bare root plants.

c. Protect balled and burlapped plants from freezing or drying out by covering the balls or roots with moist burlap, sawdust, wood chips, shredded bark, peat moss, or other approved material. Provide covering which allows air circulation.

d. Keep plants in a moist condition until planted by watering with a fine mist spray.

e. Do not store plant material directly on concrete or bituminous surfaces.

1.5.2.2 Fertilizer, Gypsum, pH Adjusters and Mulch Storage

Store in dry locations away from contaminants.

1.5.2.3 Topsoil

Prior to stockpiling topsoil, eradicate on site undesirable growing vegetation. Clear and grub existing vegetation three to four weeks prior to stockpiling existing topsoil.

1.5.2.4 Root Control Barrier and Weed Control Fabric

Store materials on site in enclosures or under protective covering in dry location. Store under cover out of direct sunlight. Do not store materials directly on ground.

1.5.3 Handling

Do not drop or dump plants from vehicles. Avoid damaging plants being moved from nursery or storage area to planting site. Handle plants carefully to avoid damaging or breaking the earth ball or root structure. Do not handle plants by the trunk or stem. Remove damaged plants from the site.

1.5.4 TIME LIMITATION

Except for container-grown plant material, the time limitation from digging to installing plant material shall be a maximum of 90 days. The time limitation between installing the plant material and placing the mulch shall be a maximum of 24 hours.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

Indicate names of plants in accordance with the LHBH, including type, quality, and size.

1.6.1 Restrictions

Do not plant when ground is frozen, snow covered, muddy, or when air temperature exceeds 32 degrees Celsius (90 degrees Fahrenheit)

1.7 GUARANTEE

All plants shall be guaranteed for one year beginning on the date of inspection by the Contracting Officer to commence the plant establishment period, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by the Government or by weather conditions unusual for the warranty period. Transplanted plants require no guarantee.

PART 2 PRODUCTS

2.1 PLANTS

2.1.1 Regulations and Varieties

Furnish nursery stock in accordance with ANSI/ANLA Z60.1, except as otherwise specified or indicated. Each plant or group of planting shall have a "key" number indicated on the nursery certifications of the plant schedule. Furnish plants, including turf grass, grown under climatic conditions similar to those in the locality of the project. Spray plants budding into leaf or having soft growth with an antidesiccant before digging. Plants of the same specified size shall be of uniform size and character of growth. All plants shall comply with all Federal and State Laws requiring inspection for plant diseases and infestation.

2.1.2 Shape and Condition

Well-branched, well-formed, sound, vigorous, healthy planting stock free from disease, sunscald, windburn, abrasion, and harmful insects or insect eggs and having a healthy, normal, and undamaged root system.

2.1.2.1 Deciduous Trees and Shrubs

Symmetrically developed and of uniform habit of growth, with straight boles or stems, and free from objectionable disfigurements.

2.1.2.2 Evergreen Trees and Shrubs

Well developed symmetrical tops with typical spread of branches for each particular species or variety.

2.1.2.3 Ground Covers and Vines

Number and length of runners and clump sizes indicated, and of the proper age for the grade of plants indicated, furnished in removable containers, integral containers, or formed homogeneous soil section.

2.1.3 Plant Size

Minimum sizes measured after pruning and with branches in normal position, shall conform to measurements indicated, based on the average width or height of the plant for the species as specified in ANSI/ANLA Z60.1. Plants larger in size than specified may be provided with approval of the Contracting Officer. When larger plants are provided, increase the ball of earth or spread of roots in accordance with ANSI/ANLA Z60.1.

2.1.4 Root Ball Size

All box-grown, field potted, field boxed, collected, plantation grown, bare root, balled and burlapped, container grown, processed-balled, and in-ground fabric bag-grown root balls shall conform to ANSI/ANLA Z60.1. All wrappings and ties shall be biodegradable. Root growth in container grown plants shall be sufficient to hold earth intact when removed from containers. Root bound plants will not be accepted.

2.1.5 Growth of Trunk and Crown

2.1.5.1 Deciduous Trees

A height to caliper relationship shall be provided in accordance with ANSI/ANLA Z60.1. Height of branching shall bear a relationship to the size and species of tree specified and with the crown in good balance with the trunk. The trees shall not be "poled" or the leader removed.

a. Single stem: The trunk shall be reasonably straight and symmetrical with crown and have a persistent main leader.

b. Multi-stem: All countable stems, in aggregate, shall average the size specified. To be considered a stem, there shall be no division of the trunk which branches more than 150 mm (6 inches) from ground level.

2.1.5.2 Palms

Palms shall have the specified height as measured from the base of the trunk to the base of the fronds or foliage in accordance with ANSI/ANLA Z60.1. The palm shall have straight trunk and healthy fronds or foliage as typical for the variety grown in the region of the project. Palms trimmed or pruned for delivery shall retain a minimum of 150 mm (6 inches) of foliage at the crown as a means of determining plant health.

2.1.5.3 Deciduous Shrubs

Deciduous shrubs shall have the height and number of primary stems recommended by ANSI/ANLA Z60.1. Acceptable plant material shall be well shaped, with sufficient well-spaced side branches, and recognized by the trade as typical for the species grown in the region of the project.

2.1.5.4 Coniferous Evergreen Plant Material

Coniferous Evergreen plant material shall have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. The coniferous evergreen trees shall not be "poled" or the leader removed. Acceptable plant material shall be exceptionally heavy, well shaped and trimmed to form a symmetrical and tightly knit plant. The form of growth desired shall be as indicated.

2.1.5.5 Broadleaf Evergreen Plant Material

Broadleaf evergreen plant material shall have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. Acceptable plant material shall be well shaped and recognized by the trade as typical for the variety grown in the region of the project.

2.1.5.6 Ground Cover and Vine Plant Material

Ground cover and vine plant material shall have the minimum number of runners and length of runner recommended by ANSI/ANLA Z60.1. Plant material shall have heavy, well developed and balanced crown with vigorous, well developed root system and shall be furnished in containers.

2.2 TOPSOIL

2.2.1 Existing Soil

Modify to conform to requirements specified in paragraph entitled "Composition."

2.2.2 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.3 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor .

2.2.4 Composition

Evaluate soil for use as topsoil in accordance with ASTM D5268. From 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 19 mm (3/4 inch), with maximum 3 percent retained on 6 mm (1/4 inch) screen. The pH shall be tested in accordance with ASTM D4972 or KS F 2103. Topsoil shall be free of sticks, stones, roots, plants, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	25-50 percent
Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Provide singly or in combination as required to meet specified requirements for topsoil. Soil conditioners shall be nontoxic to plants.

2.3.1 Lime

Commercial grade hydrated limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427, ASTM D5539 as modified herein. Shred and granulate peat to pass a 12.5 mm (1/2 inch) mesh screen and condition in storage pile for minimum 6 months after excavation. Biobased content shall be a minimum of 100 percent. Peat shall not contain invasive species, including seeds.

2.3.6 Sand

Clean and free of materials harmful to plants.

2.3.7 Perlite

Horticultural grade.

2.3.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, invasive species, including seeds, and soil stabilized with nitrogen and having the following properties:

2.3.8.1 Particle Size

Minimum percent by weight passing:

4.75 mm (No. 4 mesh) screen	95
2.36 mm (No. 8 mesh) screen	80

2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.8.3 Biobased Content

Minimum 100 percent.

2.3.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 850 micrometers (20 mesh screen), 100 percent passing thru 970 micrometers (16 mesh) screen.

2.4 PLANTING SOIL MIXTURES

100 percent topsoil as specified herein.

Sandy topsoil: one part topsoil to one part peat; clay topsoil: two parts topsoil to one part peat. Thoroughly mix all parts of planting soil mixture to a uniform blend throughout.

2.5 FERTILIZER

2.5.1 Granular Fertilizer

Organic or synthetic, granular controlled release fertilizer.

20 percent available nitrogen
20 percent available phosphorus
5 percent available potassium

2.5.2 Fertilizer Tablets

Organic or synthetic, plant tablets composed of tightly compressed fertilizer chips forming a tablet that is insoluble in water, is designed to provide a continuous release of nutrients for at least 24 months and contains the following minimum percentages, by weight, of plant food nutrients:

20 percent available nitrogen

20 percent available phosphorus
5 percent available potassium

2.6 WEED CONTROL FABRIC

2.6.1 Roll Type Polypropylene or Polyester Mats

Fabric shall be woven, needle punched or non-woven and treated for protection against deterioration due to ultraviolet radiation. Fabric shall be minimum 99 percent opaque to prevent photosynthesis and seed germination from occurring, yet allowing air, water and nutrients to pass thru to the roots. Minimum weight shall be 0.11 kg per square meter (5 ounces per square yard) with a minimum thickness of 0.50 mm (20 mils) with a 20 year (minimum) guarantee.

2.7 MULCH

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.7.1 Inert Mulch Materials

Riverbank stone, crushed pit-run rock, granite chips, marble chips, crushed bricks, or volcanic rock ranging in size from 6 to 13 mm (1/4 to 1/2 inches). Provide materials from site and construction waste to the greatest extent possible.

2.7.2 Organic Mulch Materials

Wood chips, ground or shredded bark, shredded hardwood, bark peelings, pine straw mulch, or pine needles. Biobased content shall be a minimum of 100 percent. .

2.7.3 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 65 by 65 mm (2-1/2 by 2-1/2 inch)screen. Mulch shall be cleaned of all sticks larger than 25 mm (1 inch) in diameter and plastic materials longer than 75 mm (3 inches). The material shall be treated to retard the growth of mold and fungi.

2.8 STAKING AND GUYING MATERIAL

2.8.1 Staking Material

2.8.1.1 Tree Support Stakes

Rough sawn FSC-certified or salvaged hard wood free of knots, rot, cross grain, bark, long slivers, or other defects that impair strength. Stakes shall be minimum 50 mm (2 inches) square or 64 mm (2 1/2 inch) diameter by 2.4 m (8 feet) long, pointed at one end.

2.8.1.2 Ground Stakes

FSC-certified or salvaged wood, 50 mm (2 inches) square by 0.91 m (3 feet) long, pointed at one end.

2.8.2 Guying Material

2.8.2.1 Guying Wire

12 gauge annealed galvanized steel, ASTM A580/A580M or KS D 3703.

2.8.2.2 Guying Cable

Minimum five-strand, 5 mm (3/16 inch) diameter galvanized steel cable orplastic coated.

2.8.3 Hose Chafing Guards

New or used 2 ply 19 mm (3/4 inch) diameter reinforced rubber or plastic hose, black or dark green, all of same color.

2.8.4 Flags

White surveyor's plastic tape, 150 mm (6 inches) long, fastened to guying wires or cables.

2.8.5 Turnbuckles

Galvanized or cadmium-plated steel with minimum 75 mm (3 inch) long openings fitted with screw eyes. Eye bolts shall be galvanized or cadmium-plated steel with 25 mm (one inch) diameter eyes and screw length 38 mm (1 1/2 inches), minimum.

2.8.6 Deadmen

100 by 200 mm (4 by 8 inch) rectangular or 200 mm (8 inch) diameter by 900 mm (36 inch) long, pine or fir wood material.

2.8.7 Metal Anchors

2.8.7.1 Driven Anchors

Malleable iron, arrow shaped, galvanized, sized as follows:

Tree Caliper	Anchor Size
50 mm	75 mm
75 to 150 mm	100 mm
150 to 200 mm	150 mm
200 to 250 mm	200 mm
250 to 300 mm	250 mm

Tree Caliper	Anchor Size
2 inches and under	3 inches

Tree Caliper	Anchor Size
3 to 6 inches	4 inches
6 to 8 inches	6 inches
8 to 10 inches	8 inches
10 to 12 inches	10 inches

2.8.7.2 Screw Anchors

Steel, screw type with welded-on 75 mm (3 inch) round helical steel plate, minimum 10 mm (3/8 inch) diameter, 375 mm (15 inches) long.

2.9 EDGING MATERIAL

2.9.1 Wood Edging

FSC-certified as specified in Section 06 10 00 ROUGH CARPENTRY. Redwood, Cypress, or Western Red Cedar wood edging shall be free of solvent at time of delivery. Minimum 200 by 13 mm (8 by 1/2 inch) treated in accordance with AWPA U1 and AWPA T1 with preservatives conforming to AWPA P5 before installation. Anchoring stakes shall be the same material as wood edging, 13 by 50 mm (1/2 by 2 inches), 300 mm (12 inches) long.

2.9.2 Recycled Plastic Edging

100 percent recycled polyethylene edging, resistant to insects, termites, boring worms, splintering and rotting, and shall not absorb moisture or promote bacterial growth. Minimum 1 by 4 inch, capable of bending a minimum 24 radius, integrally colored brown with slip joint connections. Anchors and stakes shall be of the same manufacturer and color as the edging.

2.9.3 Concrete Edging

Extruded or cast-in-place, as indicated, 150 by 150 mm (6 by 6 inch) concrete mowstrip. Provide tooled saw cut contraction joints to a depth of 19 mm (3/4 inch) after the surface has been finished. Provide joints every 1500 lineal mm (5 lineal feet). Provide 12.70 mm (1/2 inch) thick expansion joints at change of direction and where mowstrip abuts rigid pavement. Provide D13 (#4) reinforcement bar and other devices necessary to install and secure reinforcement. Provide a floated finish, then finish with a flexible bristle broom. 20 MPa (2500 psi) compressive concrete strength at 28 days as specified under Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.10 EROSION CONTROL MATERIALS

Erosion control material shall conform to the following:

2.10.1 Erosion Control Blanket

100 percent agricultural straw or70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 12 months.

2.10.2 Erosion Control Fabric

Fabric shall be knitted construction of polypropylene yarn with uniform mesh openings 19 to 25 mm (3/4 to 1 inch) square with strips of biodegradable paper. Filler paper strips shall have a minimum life of 6 months.

2.10.3 Erosion Control Net

Net shall be heavy, twisted jute mesh, weighing approximately 605 grams per meter (1.22 pounds per linear yard) and 1200 mm (4 feet) wide with mesh openings of approximately 25 mm (1 inch) square.

2.10.4 Hydrophilic Colloids

Hydrophilic colloids shall be physiologically harmless to plant and animal life without phytotoxic agents. Colloids shall be naturally occurring, silicate powder based, and shall form a water insoluble membrane after curing. Colloids shall resist mold growth.

2.10.5 Erosion Control Material Anchors

Erosion control anchors shall be as recommended by the manufacturer.

2.11 ROOT CONTROL BARRIER

Flexible and permeable geotextile fabric with permanently attached time-released nodules. Color to be black.

2.12 WATER

Source of water to be approved by Contracting Officer and suitable quality for irrigation and shall not contain elements toxic to plant life.

2.13 SOURCE QUALITY CONTROL

The Contracting Officer will inspect plant materials at the project site and approve them. Tag plant materials for size and quality.PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide soil preparation, fertilizing, tree, shrub, vine, groundcover, and planting, edging, staking and guying, weed control fabric, erosion control material and root control barrier installation and a mulch topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.2 PREPARATION

3.2.1 Layout

Stake out approved plant material locations and planter bed outlines on the project site before digging plant pits or beds. The Contracting Officer reserves the right to adjust plant material locations to meet field conditions. Do not plant closer than 300 mm (12 inches) to a building wall, pavement edge, fence or wall edge and other similar structures.

3.2.2 Subsoil Drainage for Plant Pits and Beds

Provide as indicated. Lay perforated drain pipe with perforations down. Backfill trenches as specified in Section 31 00 00 EARTHWORK.

3.3 PLANT BED PREPARATION

Verify location of underground utilities prior to excavation. Protect existing adjacent turf before excavations are made. Where planting beds occur in existing turf areas, remove turf to a depth that will ensure removal of entire root system. Measure depth of plant pits from finished grade. Depth of plant pit excavation shall be as indicated and provide proper relation between top of root ball and finished grade. Install plant material as specified in paragraph entitled "Plant Installation." Do not install trees within 10 feet of any utility lines or building walls.

3.4 PLANT INSTALLATION

3.4.1 Individual Plant Pit Excavation

Excavate pits at least twice as large in diameter as the size of ball or container to depth shown.

3.4.2 Plant Beds with Multiple Plants

Excavate plant beds continuously throughout entire bed as outlined to depth shown.

3.4.3 Handling and Setting

Move plant materials only by supporting the root ball or container. Set plants on hand compacted layer of prepared backfill soil mixture 150 mm (6 inches) thick and hold plumb in the center of the pit until soil has been tamped firmly around root ball. Set plant materials, in relation to surrounding finish grade, 25 to 50 mm (one to two inches) above depth at which they were grown in the nursery, collecting field or container. Replace plant material whose root balls are cracked or damaged either before or during the planting process.

Plant material shall be set in plant beds according to the drawings. Backfill soil mixture shall be placed on previously scarified subsoil to completely surround the root balls, and shall be brought to a smooth and even surface, blending to existing areas.

3.4.3.1 Balled and Burlapped Stock

Backfill with prepared soil mixture or topsoil to approximately half the depth of ball and then tamp and water. Carefully remove or fold back excess burlap and tying materials from the top a minimum 1/3 depth from the top of the rootball. Tamp and complete backfill, place mulch topdressing, and water. Remove wires and non-biodegradable materials from plant pit prior to backfill operations.

3.4.3.2 Bare-Root Stock

Plant so roots are arranged in a natural position. Place roots in water a minimum of 30 minutes prior to planting. Carefully work prepared soil mixture or topsoil among roots. Tamp remainder of backfill, place mulch topdressing and water.

3.4.3.3 Container Grown Stock

Remove from container and prevent damage to plant or root system.

3.4.3.4 Ground Covers and Vines

Plant after placing mulch topdressing. Do not remove plant materials from flats or containers until immediately before planting. Space at intervals indicated. Plant at a depth to sufficiently cover all roots. Start watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 150 mm (6 inches) without run off or puddling. Smooth planting areas after planting to provide even, smooth finish. Mulch as indicated.

3.4.4 Weed Control Fabric Installation

Remove grass and weed vegetation, including roots, from within the area enclosed by edging. Completely cover areas enclosed by edging with specified weed control fabric prior to placing mulch layer. Overlap cut edges 150 mm (6 inches).

3.4.5 Erosion Control Material

Install in accordance with manufacturer's instructions.

3.4.6 Placement of Mulch Topdressing

Place specified mulch topdressing on top of weed control fabric covering total area enclosed by edging. Place mulch topdressing to a depth of 75 mm (3 inches).

3.4.7 Mulch Topdressing

Provide mulch topdressing over entire planter bed surfaces and individual plant surfaces including earth mound watering basin around plants to a depth of 75 mm (3 inches) after completion of plant installation and before watering. Keep mulch out of the crowns of shrubs. Place mulch a minimum 50 to 75 mm (2 to 3 inches) away from trunk of shrub or tree. Place on top of any weed control fabric.

3.4.8 Installation of Edging

Uniformly edge beds of plants to provide a clear cut division line between planted area and adjacent lawn. Construct bed shapes as indicated. Install wood, plastic, concrete edging material as indicated and as per manufacturer's instructions. Install edging material in a perfect 1.22 m (4 foot) diameter circle inside the 1.37 m (4 1/2 foot) watering basin, around individual specimen trees and shrubs not planted in a close group. Install edging with minimum 25 mm (one inch) left above ground level.

3.4.9 Fertilization

3.4.9.1 Fertilizer Tablets

Place fertilizer planting tablets evenly spaced around the plant pits to the manufacturer's recommended depth.

3.4.9.2 Granular Fertilizer

Apply granular fertilizer as a top coat prior to placing mulch layer and water thoroughly.

3.4.10 Watering

Start watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 300 mm (12 inches) without run off.

3.4.11 Staking and Guying

3.4.11.1 Staking

Stake plants with the number of stakes indicated complete with double strand of 12 gage guy wire as detailed. Attach guy wire half the tree height but not more than 1.5 m (5 feet) high. Drive stakes to a depth of 0.80 to 0.91 m (2 1/2 to 3 feet) into the ground outside the plant pit. Do not injure the root ball.

3.4.11.2 Guying

Guy plants as indicated. Attach two strands of guying wire or guying cable around the tree trunk at an angle of 0.785 rad (45 degrees) at approximately 1/2 of the trunk height . Protect tree trunks with chafing guards where guying wire, cable contacts the tree trunk. Anchor guys to deadmen wood blocks, wood ground stakes, malleable iron anchors, steel screw anchors. Fasten flags to each guying wireor cable approximately 2/3 of the distance up from ground level.

3.4.11.3 Chafing Guards

Use hose chafing guards, as specified where guy wireor cable will contact the plant.

3.4.11.4 Deadmen

Place deadmen minimum 450 mm (18 inches) below ground surface. Place equal distance from tree trunk and around the plant pit.

3.4.11.5 Wood Ground Stakes

Drive wood ground stakes into firm ground outside of plant pit with top of stake flush with ground. Place equal distance from tree trunk and around the plant pit.

3.4.11.6 Iron Anchors

Drive malleable iron anchors into firm ground outside of plant pit a minimum 750 mm (30 inches) below finish grade. Place equal distance from tree trunk and around the plant pit.

3.4.11.7 Steel Screw Anchors

Insert steel screw anchors as recommended in manufacturer's data. Place equal distance from tree trunk and around the plant pit.

3.4.11.8 Flags

Securely fasten flags on each guy wire and cable approximately two-thirds of the distance up from ground level.

3.4.12 Pruning

Prune in accordance with safety requirement of TCIA Z133.1.

3.4.12.1 Trees and Shrubs

Remove dead and broken branches. Prune to correct structural defects only. Retain typical growth shape of individual plants with as much height and spread as practical. Do not cut central leader on trees. Make cuts with sharp instruments. Do not flush cut with trunk or adjacent branches. Collars shall remain in place. Pruning shall be accomplished by trained and experienced personnel and shall be accordance with TCIA A300P1.

3.4.12.2 Wound Dressing

Do not apply tree wound dressing to cuts.

3.5 RESTORATION AND CLEAN UP

3.5.1 Restoration

Turf areas, pavements and facilities that have been damaged from the planting operation shall be restored to original condition at the Contractor's expense.

3.5.2 Clean Up

Excess and waste material shall be removed from the installed area and shall be disposed offsite at an approved landfill, recycling center, or composting center. Separate and recycle or reuse the following landscape waste materials: nylon straps, wire, ball wrap, burlap, and wood stakes. Adjacent paved areas shall be cleared.

-- End of Section --

SECTION 32 96 00

TRANSPLANTING EXTERIOR PLANTS
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2014) Standard Specification for Stainless Steel Wire
ASTM C602	(2007) Agricultural Liming Materials
ASTM D4427	(2007) Peat Samples by Laboratory Testing
ASTM D4972	(2001; R 2007) pH of Soils
ASTM D5539	(1994; R 2008) Seed Starter Mix

AmericanHort (AH)

ANSI/ANLA Z60.1	(2004) American Standard for Nursery Stock

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3703	(2007) Stainless Steel Wires
KS F 2103	(2003) Testing method for pH of soils

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA A300P1	(2008) ANSI A300 Part1: Tree Care Operations - Trees, Shrubs and Other Woody Plant Maintenance Standard Practices - Pruning
TCIA Z133.1	(2006) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 RELATED REQUIREMENTS

Section 02 41 00 DEMOLITION AND DECONSTRUCTION, Section 31 00 00

EARTHWORK, Section 32 84 24 IRRIGATION SPRINKLER SYSTEMS, Section 32 92 19 SEEDING, Section 32 92 23 SODDING, Section 32 93 00 EXTERIOR PLANTS and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for requirements, with additions and modifications herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Photographs

SD-02 Shop Drawings

Transplanting Plan

SD-03 Product Data

Equipment

A listing of equipment to be used for the transplanting operation, including, size, model, year, and type of mechanical tree transplanting equipment.

SD-06 Test Reports

Soil Test; Soil Test of current growing area; Soil Test of proposed area; Soil Test location map

Percolation Test; Percolation Test of current growing area; Percolation Test of proposed area

1.4 QUALITY ASSURANCE

1.4.1 Photographs

The contractor shall provide a clear 100 mm by 150 mm (4 inch by 6 inch) minimum size color photograph of the plant material to be relocated. Trees shall be documented by an individual photograph of each. Photographs shall indicate the date and species of each plant on the back or front of each photo.

1.4.2 Transplanting Plan

A transplanting plan shall be submitted showing existing and proposed locations of transplanted material. The plan shall also delineate methods, dates, and times for root pruning, digging, balling, removing, storing, transporting, planting, watering, and maintenance to ensure survivability. The plan shall also include equipment and anti-desiccant to be used. A listing of the plant material to be transplanted shall be provided by common name and botanical name as listed under "Nomenclature" in ANSI/ANLA Z60.1; classification; caliper; and height.

1.4.3 Soil Test

Commercial test from an independent testing laboratory according to the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42 including basic soil groups (sand, silt, clay, pH (ASTM D4972 or KS F 2103), soluble salts), secondary nutrient groups (calcium, magnesium, sodium, Sodium Absorption Ratio (SAR)), micronutrients (zinc, manganese, iron, copper). Soil required for each test shall include a maximum depth of 450 mm (18 inches) of approximately 1 liter (1 quart) volume for each test. Areas sampled should not be larger than 0.4 hectare (1 acre) and should contain at least 6-8 cores for each sample area and be thoroughly mixed. Problem areas should be sampled separately and compared with samples taken from adjacent non-problem areas. The location of the sample areas should be noted and marked on a parcel or planting map for future reference.

1.4.4 Percolation Test

Immediately following rough grading operation, identify a typical location for one of the largest trees and or shrubs and excavate a pit per the project details. Fill the pit with water to a depth of 300 mm (12 inches). The length of time required for the water to percolate into the soil, leaving the pit empty, shall be measured by the project Landscape Architect and verified by the Contracting Officer. Within six hours of the time the water has drained from the pit, the Contractor, with the Contracting Officer and project Landscape Architect present, shall again fill the pit with water to a depth of 300 mm (12 inches). If the water does not completely percolate into the soil within 9 hours, a determination shall be made and submitted by the Contractor and verified and approved by the Contracting Officer, whether a drainage system or a soil penetrant will be required for each tree and or shrub being transplanted.

1.5 DELIVERY OF MATERIALS

1.5.1 Soil Conditioners Delivery and Storage

Soil conditioners shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil conditioners may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries. Store in dry locations and away from contaminants.

1.6 PLANT MATERIAL IDENTIFICATION

Plant material to be transplanted shall be tagged and/or shown on drawings. Transplanted plant material shall be delivered with attached, durable, waterproof labels and weather-resistant ink or imprinted tags, stating the correct botanical and common plant name and size.

1.7 INSPECTION OF MATERIALS

Materials shall be inspected for compliance with paragraph PRODUCTS and paragraph PLANT MATERIAL IDENTIFICATION. Open soil amendment containers or wet soil amendments shall be rejected. Topsoil that contains slag, cinders, stones, lumps of soil, sticks, roots, trash or other material larger than 40 mm (1-1/2 inch) diameter shall be rejected. Topsoil that contains viable plant material and plant parts shall be rejected. Unacceptable material shall be removed from the job site. The Contracting Officer reserves the right to refuse any unacceptable plant material. All rejected plant material shall be removed from the job site on the day of rejection.

1.8 HANDLING OF PLANT MATERIALS

Materials shall not be dropped from vehicles. Plant material shall be transported without scarring trunks or deforming crown branching. Materials found to be in unacceptable condition shall be replaced at no additional cost to the Government.

1.9 TIME LIMITATION

The time limitation from digging, removing, transporting, to installing transplanted plant material shall be the same day. The time limitation between installing the plant material and placing the mulch shall be a maximum 48 hours. If project conditions prevent the Contractor from transplanting and installing plant material on the same day, plant materials shall be boxed or heeled in as required. Plant material shall be maintained and protected by the Contractor.

1.10 GUARANTEE

Transplanted plant material shall have a guarantee period of 365 days. All plants that die or have 25 percent or more of their branches that die during the construction operations or the guarantee period, shall be replaced in kind in relation to size and species during the planting season from April to September.

1.11 TRANSPLANTED PLANT MATERIAL TIME AND CONDITIONS

1.11.1 Deciduous Plant Material Time

Deciduous plant material shall be transplanted from April to September.

1.11.2 Evergreen Plant Material Time

Evergreen plant material shall be transplanted from April to September.

1.11.3 Transplanting Conditions

All transplanting operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture, frozen ground or other unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to all transplanting operations, proposed transplanting times shall be submitted for approval. The installing site for the plant material shall be prepared and excavated in accordance with paragraph SITE EXCAVATION, prior to removing the plant material. If project conditions prevent the Contractor from transplanting and installing plant material on the same day, plant material shall be boxed or heeled in as required. Plant material shall be maintained by the Contractor until a suitable planting time.

1.11.4 Underground Utilities

The location of underground utilities and facilities at both the removal and installing sites shall be verified and marked. Damage to underground utilities and facilities shall be repaired at the Contractor's expense.

1.11.5 Protecting Existing Vegetation

When there are established lawns at either the removal or installing sites, the turf shall be protected during the operation. Existing trees, shrubs, and plant beds at the removal or installing sites that are to be preserved shall be barricaded and protected from damage by a tree barricade or other measure. Damage to existing plant material shall be mitigated by the Contractor at no additional cost to the Government.

1.11.6 Protection of Plant Material to be Transplanted

Contractor shall protect plant material slated for transplanting that is not transplanted at the beginning of construction operations. Prior to construction operations, Contractor shall tag plants to be transplanted with plastic or vinyl tape tied to the plant caliper. Plants to be transplanted shall be protected from root compaction and any other damage (with barrier of metal poles a maximum of 2.5 meters (8 feet) on center with plastic fluorescent netting) at a minimum of 6 meter (20 foot) diameter from outside of the plant's trunk prior to the start of any construction operations. Where tree drip lines are greater than 3 meter (10 feet) from the tree's trunk, locate barrier fencing at the drip line of the tree. Plastic tape and barrier fencing shall not be removed until transplanting operations are ready to begin and or instructed by the Contracting Officer. Contractor shall water and prune plant material as necessary to keep healthy and vigorous, particularly when water is shut off. Contractor shall be responsible for watering existing plant material to be transplanted from the start of construction operations until the maintenance period is over or until regular irrigation or water service is in working order. Outside storage locations shall be continually shaded and protected from the wind. Bare root plants shall be heeled in. Plants stored on the project shall be protected from any drying at all times covering the balls or roots with moist sawdust, wood chips, shredded bark, peat moss, or other similar mulching material.

1.11.7 Protection of Plant Material During Transplanting

Plant material shall be protected during transplanting to prevent desiccation and damage to the branches, trunk, and root system. Branches of shrubs, palms, vines shall be protected by tying-in. Exposed branches shall be covered during transport. Plant material shall be undamaged, vigorous and healthy with a well-branched root system, free from disease, harmful insects and insect eggs, sun-scald injury, disfigurement or abrasion after transplanting. Plant material showing desiccation, abrasion, sun scald injury or structural branching damage shall be replaced at no cost to the government.

PART 2 PRODUCTS

2.1 TOPSOIL

Topsoil to be placed around root balls of transplanted material at new planting site shall match topsoil of existing site where material is transplanted from, based on soil tests taken at both the current growing area and the proposed growing site. Minimum matching characteristics shall include: ph, organic matter, soluble salts, and percentages of silt, clay and sand. Additional topsoil shall be furnished by the Contractor unless otherwise indicated on contract drawings. Soil conditioners may be added to topsoil to bring into compliance.

2.2 SOIL CONDITIONERS

Provide singly or in combination as required to meet specified requirements for topsoil. Soil conditioners shall be nontoxic to plants.

2.2.1 Lime

Commercial grade hydrated or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.2.2 Aluminum Sulfate

Commercial grade.

2.2.3 Sulfur

100 percent elemental

2.2.4 Iron

100 percent elemental

2.2.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427 and ASTM D5539 as modified herein. Shred and granulate peat to pass a 12.5 mm (1/2 inch) mesh screen and condition in storage pile for minimum 6 months after excavation. Biobased content shall be a minimum of 100 percent. Peat shall not contain invasive species, including seeds.

2.2.6 Sand

Clean and free of materials harmful to plants.

2.2.7 Perlite

Horticultural grade.

2.2.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, invasive species, including seeds, and soil stabilized with nitrogen and having the following properties:

2.2.8.1 Particle Size

Minimum percent by weight passing:

4.75 mm (No. 4 mesh) screen	95
2.36 mm (No. 8 mesh) screen	80

2.2.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.2.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 850 micrometers (20 mesh screen), 100 percent passing thru 970 micrometers (16 mesh) screen.

2.3 MULCHES / TOP DRESSING

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.3.1 Inert Mulch Materials

Riverbank stone, crushed pit-run rock, granite chips, marble chips, crushed bricks, or volcanic rock ranging in size from 6 to 13 mm (1/4 to 1/2 inches). Provide materials from site and construction waste to the greatest extent possible.

2.3.2 Organic Mulch Materials

Wood chips, ground or shredded bark, shredded hardwood, bark peelings, pine straw mulch, pine needles from site when available. Biobased content shall be a minimum of 100 percent.

2.3.3 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 65 mm by 65 mm (2-1/2 inch by 2-1/2 inch) screen. It shall be cleaned of all sticks a minimum 25 mm (1 inch) in diameter and plastic materials a minimum 75 mm (3 inch) length. The material shall be pretreated to retard the growth of mold and fungi.

2.4 STAKING AND GUYING MATERIAL

2.4.1 Staking Material

2.4.1.1 Tree Support Stakes

Rough sawn FSC-certified or salvaged hard wood free of knots, rot, cross grain, bark, long slivers, or other defects that impair strength. Stakes shall be minimum 50 mm (2 inches) square or 64 mm (2 1/2 inch) diameter by 2.4 m (8 feet) long, pointed at one end.

2.4.1.2 Ground Stakes

Wood 50 mm (2 inches) square by 0.91 m (3 feet) long.

2.4.2 Guying Material

2.4.2.1 Guying Wire

12 gauge annealed galvanized steel, ASTM A580/A580M or KS D 3703.

2.4.2.2 Guying Cable

Minimum five-strand, 5 mm (3/16 inch) diameter galvanized steel cable.

2.4.2.3 Hose Chafing Guards

New or used 2 ply 19 mm (3/4 inch) diameter reinforced rubber or plastic hose, black or dark green, all of same color.

2.4.2.4 Flags

White 150 mm (6 inches) long, fastened to guying wires or cables.

2.4.2.5 Turnbuckles

Galvanized or cadmium-plated steel with minimum 75 mm (3 inch) long openings fitted with screw eyes. Eye bolts shall be galvanized or cadmium-plated steel with 25 mm (one inch) diameter eyes and screw length 38 mm (1-1/2 inches), minimum.

2.4.2.6 Deadmen

100 by 200 mm (4 by 8 inch) rectangular or 200 mm (8 inch) diameter by 900 mm (36 inch) long, fir wood material.

2.4.2.7 Metal Anchors

a. Driven Anchors

Malleable iron, arrow shaped, galvanized, sized as follows:

Tree Caliper	Anchor Size
50 mm	75 mm
75 to 150 mm	100 mm
150 to 200 mm	150 mm
200 to 250 mm	200 mm
250 to 300 mm	250 mm

Tree Caliper	Anchor Size
2 inches and under	3 inches
3 to 6 inches	4 inches
6 to 8 inches	6 inches
8 to 10 inches	8 inches
10 to 12 inches	10 inches

b. Screw Anchors

Steel, screw type with welded-on 75 mm (3 inch) round helical steel plate, minimum 10 mm (3/8 inch) diameter, 375 mm (15 inches) long.

2.5 WATER

Unless otherwise directed, water shall be the responsibility of the Contractor. Water shall be potable ornon-potable, supplied by an existing irrigation system.

2.5.1 Hose

Hoses used for watering shall be a minimum of 60 percent post-consumer rubber or plastic.

PART 3 EXECUTION

3.1 PLANT MATERIAL PREPARATION AND HANDLING

3.1.1 Pruning

3.1.1.1 Root Pruning

Large canopy and specimen plant material shall be root pruned a minimum of 6 months before transplanting. Minimum root ball sizes shall be in accordance with ANSI/ANLA Z60.1.

3.1.1.2 Canopy Pruning

Canopy pruning shall conform to TCIA A300P1.

3.1.2 Plant Material Preparation

Plant material designated for transplanting shall be watered thoroughly several days before root pruning, digging or moving. Broken or interfering growth shall be pruned. Large canopy and specimen plant material shall be wire balled and burlapped. Mark north side of plants prior to excavation. Relocate in new location with north facing same direction.

3.1.3 Palms

In preparation for relocation, remove all dead and green fronds below a horizontal position with clean, sterilized equipment and tools. All fronds above horizontal shall be lifted and tied together in two locations around the crown in an upright position with a light weight cotton rope. Removal of fronds and tying shall be completed prior to digging the root ball. Palms trimmed or pruned shall retain a minimum 150 mm (6 inches) of foliage at the crown as a means of determining plant health.

3.2 SITE PREPARATION

3.2.1 Finish Grade and Topsoil

The Contractor shall verify that finish grades are as indicated on drawings, and that the placing of topsoil, the smooth grading, and the compaction requirements have been completed in accordance with Section 31 00 00 EARTHWORK, prior to the commencement of the transplanting operation.

3.2.2 Layout

Relocate plant material as shown on drawings. Plant material locations may be adjusted to meet field conditions, only with Contracting Officer approval.

3.3 SITE EXCAVATION

3.3.1 Obstructions Above or Below Ground

When obstructions above or below ground affect the work, shop drawings showing proposed adjustments to plant material location, and planting method shall be submitted for Government approval.

3.3.2 Turf Removal and Replacement

Where the installation operation occurs in an existing lawn area, the turf shall be removed from the excavation area to a depth that will ensure the removal of the entire root system.

3.3.3 Plant Pits

Plant pits shall be dug to a depth equal to the height of the root ball as measured from the base of the ball to the base of the plant trunk. Plant pits shall be dug a minimum of 2 times the diameter of the root system to allow for root expansion. The pit shall be constructed with sides sloping towards the base as a cone, to encourage well-aerated soil to be available to the root system for favorable root growth. Cylindrical pits with vertical sides shall not be used. Pits shall be dug immediately before plants are placed in the pit.

3.4 INSTALLATION

3.4.1 Setting Plant Material

Plant material shall be set plumb and held in position until sufficient top soil has been firmly placed around root system or ball. In relation to the surrounding grade, the plant material shall be set even with the grade at which it was grown. The root system shall be spread out and arranged in its natural position. Damaged or girdled roots shall be removed with a clean cut. The beginning of the root flare shall be visible at soil level when the tree is planted, since it is critical not to plant the tree too deep. The following shall be performed:

a. Plumb plant materials and backfill half of the hole with topsoil.

b. Prior to backfilling, all metal, wood, and synthetic products shall be removed from the ball or root system avoiding damage to the root system. Biodegradable burlap and tying material shall be carefully opened and folded back from the top a minimum 1/3 depth from the top of the root ball.

c. Water the hole to collapse air pockets.

d. Backfill and gently firm topsoil.

e. Clear soil mounded against trunk.

f. An earth berm, consisting of backfill soil mixture, shall be formed with a minimum 100 mm (4 inch) height around the edge of the plant pit to aid in water retention and to provide soil for settling adjustments.

3.4.2 Watering

A regular watering schedule shall be established. Slow deep watering shall be used. Plant pits and plant beds shall be watered immediately after backfilling, until completely saturated. Run-off and puddling shall be prevented. Watering of other plant material or adjacent areas shall be prevented.

3.4.3 Staking and Guying

Staking will be required when trees are unstable or will not remain set due to their size, shape, or exposure to high wind velocity. When required the following staking and guying procedures shall apply:

3.4.3.1 One Bracing Stake

Trees 1200 to 1800 mm (4 to 6 feet) high shall be firmly anchored in place with one bracing stake. The bracing stake shall be placed on the side of the tree facing the prevailing wind. The bracing stake shall be driven vertically into firm ground and shall not injure the ball or root system. The tree shall be held firmly to the stake with a double strand of guying material. The guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. A chafing guard shall be used when metal is the guying material.

3.4.3.2 Two Bracing Stakes

Trees from 1800 to 2400 mm (6 to 8 feet) height shall be firmly anchored in place with 2 bracing stakes placed on opposite sides. Bracing stakes shall be driven vertically into firm ground and shall not injure the ball or root system. The tree shall be held firmly between the stakes with a double strand of guying material. The guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. Chafing guards shall be used when metal is the guying material.

3.4.3.3 Three Bracing or Ground Stakes

Trees over a minimum 2400 mm (8 feet) height and less than a maximum 150 mm (6 inch) caliper shall be held firmly in place with 3 bracing or ground stakes spaced at equal intervals around the tree. Ground stakes shall be avoided in areas to be mowed. Stakes shall be driven into firm ground outside the earth berm. The guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. For trees over a minimum 75 mm (3 inch) diameter at breast height, turnbuckles shall be used on the guying material for tree straightening purposes. One turnbuckle shall be centered on each guy line. Chafing guards shall be used when metal is the guying material.

3.4.4 Deadmen or Earth Anchors

Trees over a minimum 150 mm (6 inch) caliper shall be held firmly in place with wood deadmen buried a minimum 900 mm (3 feet) in the ground or metal earth anchors. Multi-strand cable guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. Turnbuckles shall be used on the guying material for tree straightening purposes. One turnbuckle shall be centered on each guy line. Chafing guards shall be used.

3.4.5 Flags

A flag shall be securely fastened to each guy line between the tree, stake, deadmen, or earth anchor. The flag shall be visible to pedestrians.

3.5 FINISHING

All planting operations shall conform to TCIA Z133.1.

3.5.1 Plant Material

Prior to placing mulch, the installed area shall be uniformly edged to provide a clear division line between the planted area and the adjacent turf area, shaped as indicated. The installed area shall be raked and smoothed while maintaining the earth berms.

3.5.2 Placing Mulch

The placement of mulch shall occur a maximum of 48 hours after planting. Mulch, used to reduce soil water loss, regulate soil temperature and prevent weed growth, shall be spread to cover the installed area with a minimum 75 mm (3 inch) uniform thickness. Mulch shall be kept out of the crowns of shrubs, ground cover, and vines and shall be kept off buildings, sidewalks and other facilities.

3.5.3 Pruning

Pruning shall be accomplished by a certified arborist. The pruning of trees and palms shall be in accordance with TCIA A300P1. Only dead or broken material shall be pruned from installed plants. The typical growth habit of individual plant material shall be retained. Broken branches shall be removed.

3.6 RESTORATION AND CLEAN UP

3.6.1 Restoration

Turf areas containing ruts or dead turf, as a result of work under this contract, shall be graded smooth and sodded with the same species. All pavements and facilities that have been damaged from the transplanting operation shall be restored to original condition at the Contractor's expense.

3.6.2 Backfill Removal Site Plant Pits

The Contractor shall ensure that all remaining holes from the removal site have been backfilled with on-site soil, tamped to 90 percent compaction, leveled and finished to meet existing grade after settling. Adjacent trees, shrubs, vines and groundcover destroyed by transplanting or construction operations shall be replaced in kind in relation to size and species and shall be installed in accordance with Section 32 93 00 EXTERIOR PLANTS. Turf shall be replaced with sod, and shall be installed in accordance with Section 32 92 23 SODDING.

3.6.3 Clean Up

Excess and waste material shall be removed from both removal site and the installed site and shall be disposed offsite at an approved landfill, recycling center, or composting center. Separate and recycle or reuse the following landscape waste materials: nylon straps, wire, ball wrap, burlap, and wood stakes. Adjacent paved areas shall be cleared.

3.7 PLANT ESTABLISHMENT PERIOD

The establishment period for transplanted materials shall be the same as for newly planted exterior plants and shall conform to the same requirements thereof as found in Section 32 05 33 LANDSCAPE ESTABLISHMENT, paragraph titled "Exterior Plant Establishment Period."

-- End of Section --

SECTION 33 08 55

COMMISSIONING OF FUEL FACILITY SYSTEMS

PART 1 GENERAL

1.1 SUMMARY/APPLICABILITY

This specification defines the requirements and procedures for startup and commissioning of fuel facility systems. It covers requirements for safety, Government scheduling and coordination, device testing, system flushing and cleaning, demonstration of indicated and specified system performance and final acceptance and reporting.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-3004A	(2004; C1) QUALITY SURVEILLANCE FOR FUELS, LUBRICANTS, AND RELATED PRODUCTS

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Commissioning Plan; G

SD-06 Test Reports

Piping Flushing Checklist
Piping Cleaning Checklist
Control Valve Checklist
Commissioning Report

SD-07 Certificates

Certification of Completion
Disposal of Waste Materials

1.4 SAFETY

Prior to any on-site commissioning activities, the following safety procedures shall be accomplished in all fueling areas to be commissioned under this specification section: testing/operation of emergency eyewash facilities, placement of Contractor-provided portable eyewash units within 31 meters (100 feet) or 10 seconds from the fueling point, verification of proper grounding throughout system, coordination with Government Fire and

Safety Office and Fuels personnel, placement of Contractor-provided spill pads and containment booms, placement of Contractor-provided fire extinguishers capable of extinguishing a fuel fire. Ensure that all radios/devices at all Class I, Division 1 areas are intrinsically safe.

1.5 SYSTEM SUPPLIER INVOLVEMENT

The Contractor and the System Supplier shall work together to prepare the work plan, commissioning plan, test reports and final reports. They shall both be present during all commissioning activities and shall coordinate and schedule the work during construction, testing, calibration and acceptance of the system, and operator training. The System Supplier shall be responsible to the Contractor for scheduling all Contractor, subcontractor, and manufacturer's service personnel during system startup and final commissioning.

1.6 COMMISSIONING PLAN

The Contractor shall submit a detailed written plan prepared by the system supplier for implementation of system commissioning. The commissioning plan shall specify a detailed plan incorporating in a sequenced manner all work specified in PART 3 EXECUTION of this specification section. The plan shall be submitted for Government approval 90 calendar days prior to commencement of fuel system commissioning. The plan shall include:

a. Personnel. List of Contractor's personnel by trade, list of key personnel, list of safety equipment, list of miscellaneous equipment such as two-way radios, and personnel transportation vehicles.

b. Performance Testing. Detailed equipment startup procedures and schedules to perform all system tests under each operating scenario in accordance with paragraph entitled "Performance Tests".

c. Pigging Plans. The Contractor shall submit a detailed written plan covering all aspects of the pipeline pigging operation, including anticipated pig runs, types of pigs, sequence of work, and retrieval/repair procedures. For gas-propelled pig runs, propellant shall only be used behind pigs and shall be isolated from the remaining system.

d. Test forms. Develop all test forms required for documenting the fuel system commissioning work. The format of the test forms shall follow the sequencing and terminology of the commissioning plan and shall furnish data grids and ample areas for test data recording.

e. Schedule. Schedules shall generated listing dates and durations of all commissioning activities as well as regular coordination and safety meetings and dates of key events for Government participation.

f. Fuel. Quantities of fuel needed for all commissioning activities and fuel delivery schedules. Plan shall include requirements and schedules for Government-provided materials and equipment.

g. Contingency plans. Information on spill and fire contingencies, along with the required Government Fire and Safety Office involvement and approvals.

h. Coordination with Base. Description of how Contractor and system supplier shall implement system start-up in coordination with ongoing base operations. Plan shall incorporate all phasing and work restriction requirements of the Contract Documents.

1.7 CERTIFICATION OF COMPLETION

As a prerequisite to fuel system commissioning, the Contractor shall submit a Certificate of Completion that certifies all work provided on the fuel system, except for field painting, has been inspected and approved by the specified approving authorities. Further, the Contractor shall certify on this certificate that all specified checks and inspections have been successfully completed prior to commissioning. The Contractor shall give the Contracting Officer at least 30 calendar days notice prior to commencement of fuel system commissioning. The Contractor shall submit the Certificate of Completion to the Contracting Officer at least 7 calendar days prior to commencement of system commissioning. The Contracting Officer shall then be responsible for scheduling the Government representatives and designers for participation in the inspection, performance testing, and final approval activities. Any contractual deficiencies observed shall be corrected by the Contractor without cost to the Government.

1.8 COMMISSIONING REPORT

Contractor shall prepare a commissioning report that documents the execution of the approved commissioning plan. All items of work specified in the commissioning plan shall be carried out and reported in this report unless otherwise approved by the Contracting Officer. Include as a part of this report verification letters of approved fuel storage tank hydrostatic tests and the piping hydrostatic tests, as generated under other specification sections. The commissioning report shall include the final settings of the control valves and pressure and flow switches and a copy of the PLC-generated data spreadsheets and trend analysis graphs/charts and a copy of the strip chart graphs with an explanation of what each graph indicates and what the system is doing.

1.9 DISPOSAL OF WASTE MATERIALS

The Contractor shall be responsible for properly disposing of any sludge, debris, filtration elements, and waste fuel resulting from piping and tank cleaning and flushing activities as specified. Comply with all applicable local, provincial, national, and USFK regulations for hazardous waste disposal.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Temporary flushing lines and equipment shall be equal in strength, stability, and materials to the associated permanent components; however, temporary spools may be carbon steel.

2.2 CONTRACTOR PROVIDED MATERIALS AND EQUIPMENT

The Contractor shall provide all material, equipment and labor required for proper start-up of the system(s), except for that specified to be Government furnished. Equipment shall include but not be limited to the following:

a. Temporary strainers.

b. Pipe spools to include spool pieces with a Single Point Receptacle on each end to allow defueling of the refueler tank trucks through the hydrant hose truck.

c. Flow meters.

d. Pressure Gages to include bayonet type gage to be used on the SPR on the Government truck. Gage shall be turned over to the Government after startup is complete.

e. Electronic sensors, PLC data logging feature, and strip recorders for pressure and flow recording are included in the PCP, except for a sensor and cable for the data from the Hydrant Control Valve, to be plugged into the PCP. This equipment shall be used to monitor and record the system during the "Equipment Test" and "Performance Testing" portions of this Specification Section. Recorded data shall be used by the Contractor and equipment factory representatives to achieve final control valve and equipment adjustments. Recorded data shall include:

  (1) Fueling pumps discharge pressures.

  (2) Supply Venturi flow rates.

  (3) Hydrant Control Valve pressures.

  (4) Back Pressure Control Valve upstream pressures.

  (5) Back Pressure Control Valve downstream pressures.

  (6) Return Venturi flow rates.

f. The Contractor must have on hand sufficient filter/separator elements and cartridges to adequately clean the system to aircraft quality use limits. During cleaning operation specified in paragraph below, "Cleaning, Testing and Sampling", Contractor shall provide a flow versus pressure drop graph for each filter/separator, including pantograph-mounted units. Contractor shall change elements and cartridges upon reaching a differential pressure (DP) of < 103 kPa at 38 lps (15 psi at 600 gpm) or per manufacturer's recommended maximum DP at the actual flow rate, or when pressure drop is less than previously graphed or fails to increase properly. A minimum of one complete set of coalescer cartridges and separator elements for each filter/separator shall be turned over to the Government after new coalescer cartridges and separator elements are installed in each vessel and after completion of acceptance testing.

g. The Contractor must have on hand sufficient fuel quality monitor elements to adequately clean the system to aircraft quality use limits. During cleaning operation as described in the paragraph below, "Cleaning, Testing and Sampling", Contractor shall provide a flow versus pressure drop graph for each vessel, including pantograph-mounted units. Contractor shall change elements upon reaching a differential pressure (DP) of 103 kPa at 38 (15 psi at 600 gpm) or per manufacturer's recommended maximum DP at the actual flow rate, or when pressure drop is less than previous graph or fails to increase properly. A minimum of one complete set of elements for each vessel shall be turned over to the Government after new elements are installed in each vessel and after completion of acceptance testing.

h. Refueled tanker trucks for flushing and draining of the system.

i. Hydrant hose trucks for fueling and defueling of aircraft.

j. Defuel carts for defueling operation.

k. The Contractor shall be responsible for providing the electrical power from a source identified by the Government to the testing locations.

l. Pig launching and receiving barrels.

m. Temporary filtration/strainers.

2.3 GOVERNMENT FURNISHED MATERIALS AND EQUIPMENT

The Government will furnish the following materials, equipment, and services used during the execution of the commissioning plan. Any damage caused by the Contractor's operations shall be repaired at no additional cost to the Government.

2.3.1 Fuel

The Contractor shall provide the fuel necessary for system testing. Additional fuel will be provided by the Contractor as required for satisfactory flushing of the system. Upon satisfactory completion of the flushing and cleaning operations, the Contractor shall supply the additional quantities of fuel required to complete the other work under this specification section.

The Contractor shall be responsible for the disposal of any contaminated fuel cleaning up fuel spilled as a result of defective materials or workmanship.

2.3.2 Utilities

Electric power required for the performance of the work under this specification section will be furnished at no charge to the Contractor.

PART 3 EXECUTION

3.1 PRELIMINARY REQUIREMENTS

All activities listed in paragraph "PART 3 EXECUTION" shall be performed sequentially in the order they are presented. Prior to any on-site commissioning activities, the Contractor shall ensure that all requirements of the paragraph entitled "Safety" are satisfied. Project shall be substantially complete and Contractor's work area shall be free of debris, trash and obstacles. Correct functioning of oil/water separator(s) shall be verified prior to receipt of fuel. Perform the following activities prior to receipt of fuel:

3.1.1 Electrical Preparations

Prior to energizing the electrical equipment, verify that short-circuit links have been removed from current transformer and that secondary circuits have been connected. Confirm that all tests required for fire detection and suppression systems have been performed and accepted. Verify all electrical transmitter connections and ensure proper calibration. Verify all electrical equipment meets Class I Division 1 requirements. Verify correct rotation of all motors prior to testing. Verify paddle type flow switches by physically actuating vanes and checking outputs. Conduit explosion-proof sealoffs shall be poured after initial electrical checks but before fuel receipt.

3.1.2 Emergency Fuel Shutoff (EFSO) System Testing

Prior to initial testing involving fuel, verify that each switch will trip the circuit breaker of the fuel pump and de-energize the EFSO relay and close the main emergency fuel shut-off valve or flow control valve of each filter/separator.

3.1.3 Storage Tanks

Ensure approved performance of storage tank integrity testing, hydrostatic tests, and coating application/inspection per the applicable specifications. Include verification letter of approved test results for information in commissioning report. Ensure that tank interior is clean and free of any fuel-contaminating debris. Verify operation of tank level alarms by closing tank connection valves and filling housings with fuel to confirm action. Ensure that certified strapping charts for all tanks are available for start-up personnel. Verify correct orientation of internal tank inlet diffuser.

3.1.4 Piping System

Ensure that all piping weld integrity and coating inspections have been performed per the applicable specifications. Include verification of approved test results for information in the commissioning report. Evacuate all accumulated water from piping low point drains, valve cavities, and equipment drains. Verify all bolted connections are tightness tested to required torque using a calibrated torque wrench. Verify that all pressure gauges are properly located and installed. Ensure that piping's cathodic protection system is tested and operational. Ensure that pipe marking and identification is provided as specified. Ensure that piping system thermal relief provisions are installed and operating as designed. Verify the correct installation of piping expansion loops, joints, and supports.

3.1.4.1 Pier Piping Systems

For pier delivery/receipt systems or other over-water piping installations, ensure compliance with the Contractor's previously approved spill control plans.

3.2 PREPARATIONS FOR FLUSHING

Upon completion of the construction to the satisfaction of the Contracting Officer, the Contractor shall make the following preparations for system flushing.

3.2.1 Protection Of Equipment

The following components shall be removed from the system prior to start of flushing operations and, where applicable, replaced with pipe spools of internal diameter equal to the item removed.

a. Control valves, including hydrant pit control valves if flushing outlets into tank trucks. The Contractor shall be responsible for any damage to valves left in place.

b. Flow and pressure sensors which are exposed to the system flush.

c. Coalescer and separator elements in filter/separators.

d. Elements in fuel quality monitors.

e. Venturi tubes and flow and pressure transmitters.

f. Fuel meters.

After flushing and pigging, the above items shall be reinstalled in the system and the spool sections turned over to the Contracting Officer.

3.2.2 Strainers

Temporary 40 mesh cone type strainers shall be installed in the suction line ahead of each fueling pump for the entire flushing operation. A temporary strainer should be installed immediately upstream of the product recovery tank overfill valve. Any damaged strainers shall be replaced by the Contractor at no additional cost to the Government.

3.2.3 Water Draw-Off

Remove any accumulated water from storage tanks' sumps and bottoms. Drain water and return fuel via filtration to storage tank. Repeat process until all water is removed.

3.3 SWAB PIG RUN - PNEUMATIC

Upon completion of the piping system and all associated integrity and coating tests, an initial foam swab pig cleaning run should be performed. This will provide line proving and bulk cleaning of the interior of the piping system. Contractor-provided pig launching and receiving barrels should be installed. The pig should be constructed of light (2-5 lbs/cu. ft.density) open cell polyurethane foam, with polyurethane back and transmitter cavity. Propellant shall be pressurized dry air. If piping system has previously been filled with fuel, propellant shall be pressurized nitrogen. The swab pig shall be examined after the initial run for signs of possible pipe blockage or damage which may prevent future pig runs. The Contractor shall prepare a contingency plan for retrieving a stuck pig and repairing any piping deformations per the applicable specifications. Additional runs shall be performed until the amount of collected debris is minimized, as determined by the Contracting Officer and System Supplier.

3.4 INITIAL FUEL RECEIPT

3.4.1 General

Utilize one storage tank for initial fuel receipt to isolate contaminated fuel. Initial receipt of fuel shall be done by gravity if possible. The Contractor shall station personnel throughout piping system at high point vents to bleed air. All flanges and equipment will be periodically inspected for leaks during filling procedures.

3.4.2 Storage Tanks

Receipt flow rate into an empty storage tank shall not exceed 1 meter per second (MPS) (3 feet per second (FPS)), as measured in the main receipt piping, until outlet of tank fill tube is submerged and pan/roof legs are lifted.

3.4.3 Components

Ensure that filter/separators and other vessels are filled slowly by closing outlet valves and venting through air eliminators. Downstream valves shall be throttled to maintain a packed condition in vessels throughout initial fill of piping system. Differential pressure across strainers shall be continuously monitored. Any time a strainer DP reaches 137.895 kPa (20 psig), it shall be cleaned.

3.4.4 Fuel Quality

Fuel used during initial receipt shall be considered contaminated and shall be positively isolated, with blind flanges or closed, padlocked manual valves, from any active aircraft or truck fueling operations. Fuel isolation shall continue until all flushing and cleaning is completed.

3.4.5 Fuel Receipt

3.4.5.1 Fuel Receipt by Pipeline

Start-up personnel shall meet with Government personnel in charge of existing fuel storage to discuss fuel transfer procedures. Topics shall include: methods of communication to start/stop remote transfer pumps; flow rate and head characteristics of transfer pumps; methods of restricting initial receipt flow rate; methods of straining and filtering initial receipt fuel; accommodating multiple pump starts resulting from required strainer and filter cleaning operations; required quantity of fuel to be transferred. Contractor shall provide a written summary of pipeline receipt procedures to the Contracting Officer.

3.4.5.2 Receipt by Commercial Truck

Coordinate with Government personnel to schedule quantity of trucks required. Contractor's personnel shall be positioned at each unloading island, at the pump house, and at the receipt tank, all in radio contact. Contractor shall provide a written summary of truck receipt procedures to the Contracting Officer. If truck unloading system is newly constructed, perform initial receipt, flushing, and testing prior to performance testing.

3.4.6 Initial Low Point Flush

Perform an initial low point flush operation by flushing each low point drain through a portable basket strainer for 10 seconds at a system pressure of 206.8 kPa (30 psig). Repeat flush until basket strainer collects no additional debris.

3.4.7 Storage Tank and Piping Hydrostatic Tests with Fuel

After initial receipt of fuel into storage tanks, perform tank hydrostatic tests with fuel. Remaining system piping shall be packed with fuel, following procedures outlined in paragraph "General" above. Perform piping hydrostatic tests with fuel per the applicable specifications, ensuring the piping system is completely vented of air through the piping high point vent system. Contractor shall submit a tank and piping testing checklist to ensure the requirements of this specification are met.

3.5 FLUSHING

The intent of the flushing operation is to remove bulk solids and water from the system. Flushing procedures shall precede cleaning procedures. All new and modified fuel piping, including the transfer line, receipt system piping, pier piping, pump house piping, apron loop, supply and return lines to the storage tanks, hydrant and fill stand piping, product recovery lines, and pantograph or hydrant hose truck lines shall be flushed with fuel.

3.5.1 Flushing Requirements

Begin flushing of fuel system pipelines at low flow rates using one delivery pump. Slowly increase flushing flow rate with additional pumps until a +/- 3.6 MPS (12 FPS) fuel velocity is achieved for a minimum of 30 minutes. If 3.6 MPS (12 FPS) cannot be achieved using system pumps, the Contractor shall provide additional temporary pumping capacity. For gravity, suction, or other non-pumped piping segments, minimum flushing volume shall be four times the pipe volume. Flushing shall continue until the fuel being delivered is free of construction debris to the satisfaction of the Contracting Officer. Samples of fuel shall be taken and tested by the designated Government agency and shall be free of gross contamination and visible free water, maximum of 2.11 mg/liter (.0002 oz/gallon) solids and free water not to exceed 1.892 ml/liter (.0676 fluid ounces per quart) for aviation fuel systems.

3.5.2 Fueling System Piping

The flushing of system pipelines shall be accomplished by pumping fuel from one storage tank through the fueling system piping and back to another tank. After high-speed flush of main system piping, all piping laterals shall be flushed with at least 18,927 liters (5000 gallons) of fuel. Air shall be bled from system high points. The procedure shall be continued until the fuel being delivered into the tanks is acceptable to the Contracting Officer. After the main piping system has been flushed to the satisfaction of the Contracting Officer, and periodically during the flushing operation, the Contractor shall flush all high point vents and low point drains for a minimum of 10 seconds at a pressure of 30 psig. Remove any accumulated water from storage tank sumps and bottoms. In piggable systems, all plug valves shall be flushed of all debris using the drain port at the bottom of the valve. Strainers shall be kept clean in order to insure maximum flow rate. All accumulated material from the strainers shall be reviewed and identified, including source if possible. Upon completion of the first flushing operations, the cone strainers shall be removed from the system and cleaned, reinstalled, and remain in the system. In addition, baskets from all strainers shall be removed and cleaned.

3.5.3 Piping Flushing Checklist

The Contractor shall generate a comprehensive matrix of all new and existing piping sections in the system. Matrix shall serve as an Owner's piping inventory and a checklist for all Contractor-provided flushing operations. Column entries shall include pipe section name, location, diameter, approximate length, flushing fuel velocity and volume achieved and acceptable results of sampling.

3.6 PIPE PIGGING RUNS

3.6.1 General

The Contractor shall track all pigs, using transmitter and receivers, at no less than .8 km (.5 mile) increments, and at no less than four (4) locations. The Contractor shall prepare a contingency plan for retrieving a stuck pig and repairing any piping deformations. After pigging, plug valves shall be flushed of all debris using the drain port at the bottom of the valve. The Contractor shall be responsible for insuring that the fuel that is returned to the storage tanks during the pig runs is free of gross contamination and passes the color assessment method, and meets the requirements of MIL-STD-3004A. The Contractor may need to provide temporary storage tanks for the high particulate and dark color fuel that accumulates in front of and behind each pig. The contractor will be responsible for dispose of the off-spec fuel off-base.

3.6.2 Cleaning Pig Run

Contractor-provided pig launching and receiving barrels shall be installed. Initially, a proving pig run (foam density <32 kg/m^3> (<2 lb/ft^3) should be performed to ensure the system is fully piggable. Upon completion of the successful proving pig run, the piping system shall be cleaned with a standard cleaning pig. This will provide thorough cleaning of the interior of the piping system. Cleaning pig shall be the bi-directional disk scraper style with steel body and replaceable polyurethane guiding and sealing disks, as well as gauge plates of 80 percent pipe diameter with .3175 cm (1/8-inch) segmented aluminum fins. The pig body should include bypass nozzles and transmitter cavity. Propellant shall be pressurized fuel using the main system delivery pumps. The pig shall be examined after the initial run for signs of possible pipe damage, interior slag or other adhered particles. Additional runs shall be performed until the amount of collected sludge or debris is minimized, as determined by the Contracting Officer and System Supplier.

3.6.3 Wire Brush Pig Run

After the cleaning pig runs, the piping system shall be cleaned with a wire brush style pig. This will remove weld slag and adhered particles from the system. Wire brush pig shall be the bi-directional disk style or directional cup style with two circular stainless steel wire brushes. The pig body should include bypass nozzles and transmitter cavity. Perform wire brush pig runs until the amount of collected weld slag or debris is minimized, as determined by the Contracting Officer and System Supplier.

3.7 CLEANING, TESTING, AND SAMPLING

After the completion of the initial flushing and cleaning pig runs, all new and modified piping shall be cleaned in accordance with the procedure specified hereafter. The intent of this cleaning operation is to remove trace solids and water from the system.

3.7.1 Preparation for Cleaning

Filter elements shall be installed in the filter/separators. Elements shall be installed in the fuel quality monitors. Adjust filter/separator flow control valve. Valves and equipment removed for flushing shall be reinstalled. Cone strainers shall be cleaned, reinstalled, and remain in the system. Tanks, including the product recovery tank shall be drained, vapor freed and cleaned per the tank cleaning specification. Transfer the contents from one storage tank to the other through the filter/separators for the purposes of cleaning. Provide temporary filtration as required to prevent cross-contamination of fuel.

3.7.2 Cleaning Requirements

Fuel shall be pumped through all new and existing piping sections including pantographs in the system. Fuel velocity during all cleaning operations shall be full pumping capacity. Minimum cleaning volume through non-pumped piping segments shall be four times the pipe volume. Cleaning shall continue until Contracting Officer certifies that the fuel contains 2 milligrams per gallon or less of particulate and 10 parts per million or less of free water. Perform sampling at all system discharge points, at tanks, and throughout pump house and piping system. Sampling and testing shall be done by an independent testing laboratory.

3.7.3 Cleaning Procedure

During cleaning procedure periodically bleed air through high point vents and flush low point drains for a minimum of 10 seconds at a system pressure of 206.8 kPa (30 psig). Monitor pressure drop through the filter/separators and fuel quality monitor including pantograph-mounted units during each cleaning operation and provide flow vs. pressure drop graphs. Any time filter/separator or fuel quality monitor DP reaches its maximum allowable value, vessel elements should be replaced. In piggable systems, all plug valves shall be flushed of all debris using the drain port at the bottom of the valve.

3.7.4 Piping Cleaning Checklist

The Contractor shall generate a comprehensive matrix of all new and existing piping sections in the system. Matrix shall serve as a checklist for all Contractor-provided cleaning operations. Column entries shall include pipe section name, location, diameter, approximate length, fuel velocity and volume achieved, and acceptable results of sampling.

3.8 CONTROL VALVE AND VENTURI ADJUSTMENT

All control valve settings shall be checked and field adjusted from the factory settings at start-up as necessary to provide a smooth operation. Adjustments to valves shall be made only by the Valve Manufacturer's authorized Field Test Engineer.

3.8.1 Control Valve Checklist

The Contractor shall generate a comprehensive matrix of all control valves in the system. Matrix shall serve as a checklist of all required control valve features, settings, and functions as specified. Column entries shall include control valve name, valve tag, pilot features, solenoid control features (if applicable), factory settings, and field adjusted settings. Submit matrix with commissioning "Final Reports".

3.8.2 Venturi Adjustment

Calibrate and adjust each venturi and its associated transmitter readout to demonstrate accurate florae measurement.

3.8.3 Pantograph Venturi Needle Valve

Venturi needle valve shall be adjusted to ensure a pressure equal to nozzle pressure at maximum flow possible. After initial setting, valve shall be locked in adjusted position.

3.9 EQUIPMENT TESTS

After completion of flushing, cleaning, and control valve and electrical component adjustments, the equipment performance tests specified hereafter shall be performed. After cleaning is complete and prior to performance testing, field adjustment of automatic control valves and automatic pump controls while in operation shall be made only by the valve manufacturer's authorized field test engineer. For final adjustment of installed electrical control equipment the Contractor shall provide an experienced electrical engineer. Both the mechanical and electrical components shall be adjusted concurrently. Tests will be witnessed by the Contracting Officer and other Government representatives.

3.9.1 Emergency Fuel Shutoff System

With one fueling pump operating, test each "Emergency Stop" pushbutton station to verify that the pump stops, the main emergency shutoff valve,and fuel control valve of each filter/separator closes. Demonstrate operation of the EFSO station at the control center. Repeat this procedure for each fueling pump and "Emergency Stop" pushbutton station. Conduct tests for both the automatic and manual modes. With all the fueling pumps circulating fuel through the system, push an "Emergency Stop" pushbutton station, ensure all pumps stop, and emergency fuel shutoff valves close.

3.9.2 Filter/Separator Control Valve

Using the manual float control test lever on each filter/separator, slowly lift the weight from the float ball and verify the operation and closure of the water slug shut-off feature on the Filter/Separator Control Valve.

3.10 3.10 PERFORMANCE TESTS

During performance testing, the Contractor shall demonstrate that all portions of the fuel system are operating as designed and specified. Tests shall be performed under all operating scenarios. Additional tests may be required by the Contracting Officer to fully demonstrate system performance. These tests shall be accomplished by the Contractor at no additional cost to the Government. The Contractor shall notify the Contracting Officer 15 calendar days in advance of the test. Record required data necessary to prepare reports specified in paragraph entitled "Commissioning Report".

3.10.1 Fuel Receipt Systems

3.10.1.1 Aboveground systems

Demonstrate the following features:

a. Static and continuity ground verification system.

b. Manual start/stop pushbutton control.

c. Level probe interconnection with flow control valve solenoids.

d. Pump shutdown upon no-flow/empty off-loading tanker condition signal from flow switch.

e. Receipt meter performance and verification of proper calibration.

3.10.1.2 Drop tank systems

Demonstrate the following features:

a. Tank overfill valve closure upon tank high level condition.

b. Level alarm actuation.

c. On/off staging of pump by tank level alarms/probes.

d. Pump shutdown on tank low level condition.

e. Tank leak detection system performance (remove probe and actuate by dipping into water/fuel test buckets).

f. Manual start/stop pushbutton control.

g. Tank gauging system.

h. Pump shutdown upon no-flow condition signal from flow switch.

i. Receipt meter performance and verification of proper calibration.

Demonstrate all other tank features and functions per the applicable specifications.

3.10.2 Storage Tank Systems

Demonstrate the following features:

a. Tank overfill valve closure upon tank high level condition.

b. Level alarm actuation.

c. Pump shutdown on tank low level condition.

d. Tank leak detection system performance (remove probe and actuate by dipping into water/fuel test buckets).

f. Tank gauging system.

g. Fire detection/suppression system performance (if AFFF system is used, do not test into tanks).

Ensure certified strapping charts are provided to the Contracting Officer. Demonstrate all other tank features and functions per the applicable specifications.

3.10.3 Transfer/Delivery Systems

Demonstrate the following features:

a. Manual start/stop pushbutton control.

b. Pump shutdown upon no-flow condition signal from flow switch,

c. Pump shutdown upon signal from remote EFSO switch.

3.10.4 Hydrant Systems

Demonstrate the following features:

a. Operation of all pressure and flow devices to automatically start and stop the fueling pumps at the indicated pressures and flow rates. The operating sequence shall be repeated with each of the pumps being selected as lead pump.

b. Completely redundant, independent programmable logic controller capability.

c. System's ability to deliver fuel to multiple fueling points at specified flow rates.

d. Hydrant control valve surge shutdown and pressure control features.

e. Defueling performance of system under static conditions, with one fueling pump operating, and in the "Flush" mode.

f. Operation of HSV/Pantograph checkout and flushing station.

g. System performance in all operating and pressure test/leak detection modes.

h. Operation of emergency generators during a simulated power outage.

3.10.5 Truck Fill Stands

Demonstrate the following features:

a. Manual start/stop pushbutton control.

b. Static and continuity ground verification (with actual ground/continuity readings) and overfill prevention system.

c. Control valve deadman control, surge shutdown, and pressure control features.

d. Issue meter performance and preset controls and verification of proper calibration.

e. Control valve and meter preset interconnections for flow control and automatic shutdown.

f. Additive injector system.

g. Bypass mode.

3.10.6 Satisfactory Performance

In the event a portion of the system or any piece of equipment fails to pass the test, the Contractor shall make the necessary repairs or adjustments and repeat the Performance Test until satisfactory performance is obtained. Any component found not to be working as specified shall be repaired/replaced by the Contractor at no additional cost to the Government. The determination of satisfactory performance shall be made by the Contracting Officer and Government representatives. The system shall be filled with fuel and shall be operable and leak-free prior to acceptance. The Contractor shall be responsible for any leaks in the new or modified portions of the system. Anything wet with fuel is considered to be leaking.

3.11 TRAINING / INSTRUCTION FOR GOVERNMENT PERSONNEL

The Government will provide one or two key personnel from their operations and maintenance department to participate in all phases of system commissioning. The Contractor and System Supplier will be responsible for coordinating the involvement and training of these individuals during the startup process, including hands-on familiarization and adjustment of devices, valves, and components.

In addition, the Contractor and System Supplier shall conduct two 8-hour formal training sessions at the conclusion of system performance testing. These sessions shall include initial classroom system presentations as well as a complete system walk-through. The function, operation and maintenance procedures for all system devices and components will be explained. Training shall be videotaped and submitted in CD ROM or DVD format.

3.12 PROJECT CLOSEOUT

Ensure that As-Built drawings, equipment warranty documentation, and other project closeout activities are completed per the requirements of the applicable specifications.

-- End of Section --

SECTION 33 11 00

WATER DISTRIBUTION
02/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2010) Manual for Railway Engineering

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2010; Addenda 2011) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2010) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C153/A21.53	(2011) Ductile-Iron Compact Fittings for Water Service
AWWA C200	(2005) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C205	(2007) Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied
AWWA C206	(2011) Field Welding of Steel Water Pipe

AWWA C207	(2007) Standard for Steel Pipe Flanges for Waterworks Service-Sizes 100 mm through 3600 mm 4 in. through 144 in.
AWWA C208	(2007; Errata 2009) Standard for Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	(2006) Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fitting for Steel Water Pipelines
AWWA C210	(2007) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C300	(2011) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type
AWWA C301	(2007) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
AWWA C303	(2008) Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C502	(2005) Dry-Barrel Fire Hydrants
AWWA C503	(2005) Wet-Barrel Fire Hydrants
AWWA C504	(2010) Standard for Rubber-Seated Butterfly Valves
AWWA C508	(2009) Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In. (600 mm) NPS
AWWA C509	(2009) Resilient-Seated Gate Valves for Water Supply Service
AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C605	(2005) Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
AWWA C606	(2011) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C700	(2009) Standard for Cold Water Meters - Displacement Type, Bronze Main Case
AWWA C701	(2012) Standard for Cold-Water Meters - Turbine Type for Customer Service

AWWA C702	(2010) Cold-Water Meters - Compound Type
AWWA C703	(1996; R 2004) Cold-Water Meters - Fire Service Type
AWWA C704	(2008) Propeller-Type Meters for Waterworks Applications
AWWA C706	(2010) Direct-Reading, Remote-Registration Systems for Cold-Water Meters
AWWA C707	(2010) Encoder-Type Remote-Registration Systems for Cold-Water Meters
AWWA C800	(2005) Underground Service Line Valves and Fittings
AWWA C900	(2007; Errata 2008) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA C901	(2008) Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13mm) Through 3 In. (76 mm), for Water Service
AWWA C905	(2010) Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings 14 In. Through 48 In. (350 mm through 1,200 mm) for Water Transmission and Distribution
AWWA C906	(2007) Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 63 In., (1,575 mm) for Water Distribution and Transmission
AWWA C909	(2009) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 IN through 24 IN (100 mm Through 600 mm), for Water, Wastewater, and Reclaimed Water Service
AWWA M11	(2004; 4th Ed) Manual: Steel Water Pipe: A Guide for Design and Installation
AWWA M23	(2002; 2nd Ed) Manual: PVC Pipe - Design and Installation
AWWA M9	(20083rd Ed) Manual: Concrete Pressure Pipe

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250

ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A746	(2009) Standard Specification for Ductile Iron Gravity Sewer Pipe
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B42	(2010) Standard Specification for Seamless Copper Pipe, Standard Sizes

ASTM B61	(2008) Standard Specification for Steam or Valve Bronze Castings
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2464	(2013) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2013a) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

ASTM F1483	(2005) Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe
ASTM F402	(2005) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS B 1507	(2004) Flexible grooved joint for steel pipe
KS B 1533	(2009) Screwed Type Steel Pipe Fittings
KS B 2301	(2009) Bronze Gate, Globe, Angle and Check Valves
KS D 3507	(2008) Carbon Steel Pipes for Ordinary Piping
KS D 3626	(2003) Coated steel pipes for water services
KS D 4301	(2006) Grey Iron Castings
KS D 4308	(2012) Ductile Iron Fittings
KS D 4311	(2010) Ductile Iron Pipes
KS D 4316	(2012) Mortar Lining of Ductile Iron Pipes & Fittings
KS D 4323	(2008) Ductile iron pipes for sewage applications
KS D 5301	(2009) Copper and Copper Alloy Seamless Pipes and Tubes
KS D 8307	(2001) Coal-tar Enamel Protective Coatings for Steel Water Pipe
KS F 4009	(2011) Ready-Mixed Concrete

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24	(2013) Standard for the Installation of Private Fire Service Mains and Their

	Appurtenances
NFPA 704	(2007) Standard System for the Identification of the Hazards of Materials for Emergency Response

UNDERWRITERS LABORATORIES (UL)

UL 246	(1993; Reprint Jun 2008) Hydrants for Fire-Protection Service
UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 312	(2010) Check Valves for Fire-Protection Service
UL 789	(2004; Reprint Aug 2008) Standard for Indicator Posts for Fire-Protection Service

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-3	(1992) Recommended Practice for the Installation of Polyvinyl Chloride (PVC) Pressure Pipe (Nominal Diameters 4-36 Inch)
UBPPA UNI-B-8	(2000) Recommended Practice for the Direct Tapping of Polyvinyl Chloride (PVC) Pressure Water Pipe (Nominal Diameters 6-12 Inch)

1.2 DESIGN REQUIREMENTS

1.2.1 Water Distribution Mains

Provide water distribution mains indicated aslines of ductile-iron polyvinyl chloride (PVC) plastic molecularly oriented Polyvinyl Chloride (PVCO) pressure steel or pipe. Provide water main accessories, gate valves and check valves as specified and where indicated. Submit design calculations of water piping.

1.2.2 Water Service Lines

Provide water service lines indicated as lines from water distribution main to building service at the points indicated. Water service lines shall be copper pipe copper tubing polyvinyl chloride (PVC) plastic pipe or steel pipe. Ductile-iron or polyvinyl chloride (PVC) plastic pipe appurtenances, and valves as specified for water mains may also be used for service lines. Provide water service line appurtenances as specified and where indicated. Submit design calculations of water piping.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Piping Materials

Water distribution main

Water service line

Hydrants; G

Indicator posts; G

Corporation stops

Valve boxes

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

SD-05 Design Data

Design calculations of water piping

SD-06 Test Reports

Bacteriological Disinfection; G.

Test results from commercial laboratory verifying disinfection

SD-07 Certificates

Water distribution main

Water service line

Shop-applied lining and coating

Lining

Fire hydrants

Displacement Type Meters

Compound Type Meters

Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal of certificates on the same type, class, grade, and size of material as is being provided for the project.

SD-08 Manufacturer's Instructions

Delivery, storage, and handling

Installation procedures for water piping

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves and hydrants free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, valves, hydrants, and other accessories in a manner to ensure delivery to the trench in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place any other material or pipe inside a pipe or fitting after the coating has been applied. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material without additional expense to the Government. Store rubber gaskets that are not to be installed immediately, under cover out of direct sunlight.

1.4.2.1 Coated and Wrapped Steel Pipe

Handle steel pipe with coal-tar enamel or coal-tar epoxy coating in accordance with the provisions of AWWA C203.

1.4.2.2 Polyethylene (PE) Pipe, Fittings, and Accessories

Handle PE pipe, fittings, and accessories in accordance with AWWA C901.

1.4.2.3 Miscellaneous Plastic Pipe and Fittings

Handle Polyvinyl Chloride (PVC), pipe and fittings in accordance with the manufacturer's recommendations. Store plastic piping and jointing materials that are not to be installed immediately under cover out of direct sunlight.

Storage facilities shall be classified and marked in accordance with NFPA 704.

PART 2 PRODUCTS

2.1 WATER DISTRIBUTION MAIN MATERIALS

2.1.1 Piping Materials

2.1.1.1 Ductile-Iron Piping

a. Pipe and Fittings: Pipe, except flanged pipe, AWWA C151/A21.51 or

KS D 4311. Flanged pipe, AWWA C115/A21.15. Fittings, AWWA C110/A21.10 or AWWA C153/A21.53 . Fittings shall have pressure rating at least equivalent to that of the pipe. Ends of pipe and fittings shall be suitable for the specified joints. Pipe and fittings shall have cement-mortar lining, AWWA C104/A21.4 or KS D 4316, standard thickness.

b. Joints and Jointing Material:

(1) Joints: Joints for pipe and fittings shall be push-on joints or mechanical joints unless otherwise indicated. Provide mechanical joints where indicated. Provide mechanically coupled type joints using a sleeve-type mechanical coupling where indicated. Provide insulating joints where indicated.

(2) Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly, AWWA C111/A21.11.

(3) Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets, AWWA C111/A21.11.

(4) Flanged Joints: Bolts, nuts, and gaskets for flanged connections as recommended in the Appendix to AWWA C115/A21.15. Flange for setscrewed flanges shall be of ductile iron, ASTM A536, Grade 65-45-12, and conform to the applicable requirements of ASME B16.1, Class 250. Setscrews for setscrewed flanges shall be 1310 MPa (190,000 psi) tensile strength, heat treated and zinc-coated steel. Gasket and lubricants for setscrewed flanges, in accordance with applicable requirements for mechanical-joint gaskets specified in AWWA C111/A21.11. Design of setscrewed gasket shall provide for confinement and compression of gasket when joint to adjoining flange is made.

(5) Insulating Joints: Designed to effectively prevent metal-to-metal contact at the joint between adjacent sections of piping. Joint shall be of the flanged type with insulating gasket, insulating bolt sleeves, and insulating washers. Gasket shall be of the dielectric type, full face, and in other respects as recommended in the Appendix to AWWA C115/A21.15. Bolts and nuts, as recommended in the Appendix to AWWA C115/A21.15.

(6) Sleeve-Type Mechanical Coupled Joints: As specified in paragraph entitled "Sleeve-Type Mechanical Couplings."

2.1.1.2 Polyvinyl Chloride (PVC) Plastic Piping

a. Pipe and Fittings: Pipe, AWWA C900, shall be plain end or gasket bell end, Pressure Class 150 (DR 18) with cast-iron-pipe-equivalent OD. Molecularly Oriented Polyvinyl Chloride (PVCO) pressure pipe, AWWA C909,shall be plain end or gasket bell end, Pressure Class 150 with cast-iron-pipe-equivalent outside diameter.

b. Pipe 350 through 900mm 14 through 36 diameter: AWWA C905.

c. Fittings for PVC pipe: Fittings shall be gray iron or ductile iron, AWWA C110/A21.10 or AWWA C153/A21.53 or KS D 4308, and have cement-mortar lining, AWWA C104/A21.4 or KS D 4316, standard thickness. Fittings with push-on joint ends shall conform to the same requirements as fittings with mechanical-joint ends, except that bell design shall be modified, as approved, for push-on joint suitable for use with PVC plastic pipe specified in this paragraph. Iron fittings and specials shall be cement-mortar lined in accordance with AWWA C104/A21.4 or KS D 4316. Fittings and specials may be of the same material as the pipe with elastomeric gaskets, all in conformance with AWWA C605 and AWWA C900. Pipe, couplings and fittings for PVCO plastic pipe shall be manufactured of material conforming to ASTM F1483 and ASTM D1784, Class 12454-B. Schedule 80 PVC fittings shall conform to ASTM D2467.

d. Joints and Jointing Material: Joints for pipe shall be push-on joints, ASTM D3139. Joints between pipe and metal fittings, valves, and other accessories shall be push-on joints ASTM D3139, or compression-type joints/mechanical joints, ASTM D3139 and AWWA C111/A21.11. Provide each joint connection with an elastomeric gasket suitable for the bell or coupling with which it is to be used. Gaskets for push-on joints for pipe, ASTM F477. Gaskets for push-on joints and compression-type joints/mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories, AWWA C111/A21.11, respectively, for push-on joints and mechanical joints. Mechanically coupled joints using a sleeve-type mechanical coupling, as specified in paragraph entitled "Sleeve-Type Mechanical Couplings," may be used as an optional jointing method in lieu of push-on joints on plain-end PVC plastic pipe, subject to the limitations specified for mechanically coupled joints using a sleeve-type mechanical coupling and to the use of internal stiffeners as specified for compression-type joints in ASTM D3139.

2.1.1.3 Polyethylene (PE) Plastic Piping

Pipe, tubing, and heat-fusion fittings shall conform to AWWA C906.

2.1.1.4 Reinforced and Prestressed Concrete Piping

a. Piping and Fittings: Prestressed steel cylinder type reinforced concrete pipe, AWWA C301. Steel cylinder type reinforced concrete pipe, not prestressed, AWWA C300. Pretensioned steel cylinder type reinforced concrete pipe, AWWA C303. Pipe shall be designed for the following minimum conditions:

Pressure rating - as indicated

Earth cover - as indicated

Water hammer - 40 percent of pressure rating

Live load - AASHTO H 20 truck loading

Do not order pipe until design calculations have been approved. Fittings shall conform to the same specification as that used for the pipe and shall be designed as specified for the pipe. Cement used in the manufacture of the pipe and fittings shall be Type II or Type V, as indicated on drawings, conforming to ASTM C150/C150M. Identification marking for pipe and fittings shall include the pressure rating.

b. Jointing Material: Gaskets shall be as specified in the referenced specification for the pipe. Rubber-gasket joints shall be of the type using a bell and spigot joint design of steel.

2.1.1.5 Steel Piping

a. Pipe and Fittings: Pipe, AWWA C200. Fittings, AWWA C208 and to AWWA C200, with reference to the requirements specified therein for "Special Sections." Pipe and fittings shall have cement-mortar lining and cement-mortar, coal-tar enamel or coal-tar epoxy coating. Pipe and fittings for aboveground lines shall have cement-mortar lining. Ends of pipe and fittings shall be suitable for the joints and jointing materials used.

   1. Pipe shall be welded or seamless with plain or shouldered and grooved ends in accordance with AWWA C606 or KS B 1507 for use with mechanical couplings or bell-and-spigot ends with rubber gaskets. Bell-and-spigot ends for sizes less than 150 mm (6 inches) diameter shall be as required by AWWA C200.

   2. Fittings and specials shall be made of the same material as the pipe. Specials and fittings may be made of standard steel tube turns or segmentally welded sections, with ends to accommodate the type of couplings or joints specified for the pipe. The thickness rating of pipe fittings and specials shall be not less than the thickness specified and the pressure rating calculated for the pipe with which they are used. Protective materials for fittings and specials shall be as specified for the pipe. Specials and fittings that cannot be mechanically lined, coated, and wrapped shall be lined, coated, and wrapped by hand, using the same material used for the pipe with the same number of applications of each material, smoothly applied.

b. Wall Thickness for Pipe and Fittings: Wall thickness of steel pipe and fittings shall be determined by the manufacturer of the pipe and calculated in the following manner. Design for the following minimum conditions:

   Pressure rating..........1000 kPa (150 psi)

   Earth cover.............1.5 m (5 feet)

   Water hammer.............40 percent of pressure rating

   Live load................AASHTO H 20 truck loading

   Allowable deflection.....2 percent of nominal pipe diameter

Calculate pipe wall thickness on the basis of an allowable fiber stress in the steel equal to 50 percent of the minimum yield strength of the steel used in the manufacture of the pipe. Design procedure shall be in accordance with the methods given in AWWA M11, Chapter 4, "Determination of Pipe Wall Thickness," Chapter 5, "Water Hammer and Pressure Surge," and Chapter 6, "External Load." The value of E', modulus of soil reaction, shall be based on realistic expectations of side fill compaction rather than theoretical ones. Do not order the pipe until calculations have been approved. Wall thickness of fittings shall be not less than that required for the pipe. Fittings shall be designed to withstand the hydrostatic pressure test specified herein in paragraphs entitled "Testing Procedure," and "Special Testing Requirements." When necessary to meet the pressure test requirements, fittings shall be reinforced in accordance with methods given in AWWA M11, Chapter 13, "Supplementary Design Data and Details."

c. Joints and Jointing Materials

(1) Joints: Joints for pipe and fittings shall be rubber-gasketed bell-and-spigot joints , welded joints, or the mechanically coupled type using a sleeve-type mechanical coupling , unless otherwise specified. Provide flanged joints where indicated. Provide mechanically coupled type joints using a sleeve type mechanical coupling where indicated. Joints shall be grooved or shouldered type where indicated. Provide insulating joints where indicated.

(2) Rubber-Gasketed Bell-and-Spigot Joints: Design of joints and pipe ends shall be in accordance with the pipe manufacturer's standard for this type of joint, as approved, except that the joint shall also meet the requirements specified for rubber-gasketed joints and rubber gaskets in AWWA C200.

(3) Welded Joints: Electrodes shall be of the quality specified in AWWA C206.

(4) Sleeve-Type Mechanical Coupled Joints: As specified in paragraph entitled "Sleeve-Type Mechanical Couplings."

(5) Grooved and Shouldered Type Joints: Pipe ends shall be grooved by roll grooving or shall have welded-on adapters with cut grooves. Grooves made by roll grooving shall have dimensions as recommended by the coupling manufacturer. Cut grooves in adapters shall have dimensions conforming to AWWA C606 or KS B 1507. Couplings and shouldered pipe ends, AWWA C606 or KS B 1507. Joint dimensions shall be as specified in AWWA C606 or KS B 1507 for rigid joint , except that where joints are indicated to be flexible, joint dimensions shall be as specified for flexible joints.

(6) Flanged Joints: Provide pipe ends with steel flanges, AWWA C207; Class D or KS D 3626. Bolts and nuts for flanged connections, AWWA C207 or KS D 3626. Rubber gaskets, AWWA C207 or KS D 3626; asbestos gaskets will not be allowed.

(7) Insulating Joints: Design to prevent metal-to-metal contact at the joint between adjacent sections of piping. Joint shall be of the flanged type with insulating gasket, insulating bolt sleeves, and insulating washers. Gasket shall be of the dielectric type, full face, and in other respects as recommended in the Appendix to AWWA C115/A21.15. Bolts and nuts shall be as recommended in the Appendix to AWWA C115/A21.15.

d. Lining and Coating:

(1) Cement-Mortar Lining: AWWA C205, shop-applied.

(2) Cement-Mortar Coating: AWWA C205, shop-applied.

(3) Coal-Tar Enamel Coating: Except as otherwise specified, prepare, prime, and coat piping with hot-applied coal-tar enamel and a bonded single layer of felt wrap in accordance with AWWA C203 or KS D 8307. Asbestos felt shall not be used; felt material shall be fibrous-glass mat as specified in Section 10 of AWWA C203 or KS D 8307. Shop-apply coating.

(4) Coal-Tar Epoxy Coating: Clean, prime, and topcoat piping with coal-tar epoxy coating system in accordance with AWWA C210. Shop-apply coating.

2.1.1.6 Piping Beneath Railroad Right-of-Way

Piping passing under the right-of-way of a commercial railroad shall conform to the specifications for pipelines conveying nonflammable substances in Chapter 1, Part 5 of the AREMA Eng Man, except for casing pipe, provide ductile-iron pipe in lieu of cast-iron pipe. Ductile-iron pipe shall conform to and have strength computed in accordance with ASTM A746 or KS D 4323.

2.1.2 Valves, Hydrants, and Other Water Main Accessories

2.1.2.1 Gate Valves on Buried Piping

AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to: (1) AWWA C500 shall be nonrising stem type with double-disc gates and mechanical-joint ends or push-on joint ends as appropriate for the adjoining pipe, (2) AWWA C509 shall be nonrising stem type with mechanical-joint ends or resilient-seated gate valves 80 to 300 mm (3 to 12 inches) in size, and (3) UL 262 shall be inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 1200 kPa (175 psi), and shall have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Valves shall open by counterclockwise rotation of the valve stem. Stuffing boxes shall have 0-ring stem seals, except for those valves for which gearing is specified, in which case use conventional packing in place of 0-ring seal. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. In lieu of mechanical-joint ends and push-on joint ends, valves may have special ends for connection to cement piping or to sleeve-type mechanical coupling. Valve ends and gaskets for connection to cement piping or to sleeve-type mechanical coupling shall conform to the applicable requirements specified for the joint or coupling. Where a post indicator is shown, the valve shall have an indicator post flange; indicator post flange for AWWA C500 valve shall conform to the applicable requirements of UL 262. Provide valves with bypasses, AWWA C500. Valves shall be of one manufacturer.

2.1.2.2 Gate Valves in Valve Pit(s) and Aboveground Location

AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to: (1) AWWA C500 shall be outside-screw-and-yoke rising-stem or nonrising stem type with double-disc or solid-wedge gates and flanged ends, (2) AWWA C509 shall be outside-screw-and-yoke rising-stem or nonrising stem type with flanged ends, and (3) UL 262 shall be outside-screw-and-yoke or inside-screw type, shall have double-disc or split-wedge or solid or one-piece type gate and flanged ends. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Valves shall be nonrising stem type or inside-screw type where indicated. Valves shall have solid-wedge gates or solid or one-piece type gates where indicated. Provide valves with hand wheels that open by counterclockwise rotation of the valve stem. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. In lieu of flanged ends, valves may have grooved or shouldered ends suitable for grooved or shouldered type joints, as specified in paragraph entitled "Ductile-Iron Piping." Valves shall have gearing and indicator, AWWA C500. Provide valve with bypasses, AWWA C500. Valves shall be of one manufacturer.

2.1.2.3 Check Valves

Swing-check type, AWWA C508 or UL 312. Valves conforming to: (1) AWWA C508 shall have iron or steel body and cover and flanged ends, and (2) UL 312 shall have cast iron or steel body and cover, flanged ends. Materials for UL 312 valves shall conform to the reference standards specified in AWWA C508. Valves shall have clear port opening. Valves shall be spring-loaded or weight-loaded where indicated. Flanges shall be Class 125 conforming to ASME B16.1. In lieu of flanged ends, valves may have grooved or shouldered ends suitable for grooved or shouldered type joints, as specified in paragraph entitled "Ductile-Iron Piping." Valves shall be of one manufacturer.

2.1.2.4 Rubber-Seated Butterfly Valves

Rubber-seated butterfly valves shall conform to the performance requirements of AWWA C504. Wafer type valves conforming to the performance requirements of AWWA C504 in all respects, but not meeting laying length requirements will be acceptable if supplied and installed with a spacer providing the specified laying length. All tests required by AWWA C504 shall be met. Flanged-end valves shall be installed in an approved pit and provided with a union or sleeve-type coupling in the pit to permit removal. Mechanical-end valves 80 through 250 mm (3 through 10 inches) in diameter may be direct burial if provided with a suitable valve box, means for manual operation, and an adjacent pipe joint to facilitate valve removal. Valve operators shall restrict closing to a rate requiring approximately 60 seconds, from fully open to fully closed.

2.1.2.5 Pressure Reducing Valves

Pressure reducing valves shall maintain a constant downstream pressure regardless of fluctuations in demand. Valves shall be suitable for the operating pressure on the inlet side, with outlet pressure set as indicated on drawings. The valves shall be of the hydraulically-operated, pilot controlled, globe or angle type, and may be actuated either by diaphragm or piston. The pilot control shall be the diaphragm-operated, adjustable, spring-loaded type, designed to permit flow when controlling pressure exceeds the spring setting. Ends shall be threaded or flanged. Valve bodies shall be bronze, cast iron or cast steel with bronze trim. Valve stem shall be stainless steel. Valve discs and diaphragms shall be synthetic rubber. Valve seats shall be bronze. Pilot controls shall be bronze with stainless steel working parts.

2.1.2.6 Vacuum and Air Relief Valves

Vacuum and air relief valves shall be of the size shown and shall be of a type that will release air and prevent the formation of a vacuum. The valves shall automatically release air when the lines are being filled with water and shall admit air into the line when water is being withdrawn in excess of the inflow. Valves shall be iron body with bronze trim and stainless steel float.

2.1.2.7 Fire Hydrants

Dry-barrel type , except that flush-type hydrants shall be provided where indicated. Paint hydrants with at least one coat of primer and two coats of yellow enamel paint, except use red enamel paint for tops of hydrants in non-potable water systems. Stencil hydrant number and main size on the hydrant barrel using black stencil paint.

a. Dry-Barrel Type Fire Hydrants: Dry-barrel type hydrants, AWWA C502 or UL 246, "Base Valve" design, shall have 150 mm (6 inch) inlet, 135 mm (5.25 inch) valve opening, one 115 mm (4.5 inch) pumper connection, and two 65 mm (2.5 inch) hose connections. Inlet shall have mechanical-joint or push-on joint end , except where flanged end is indicated; end shall conform to the applicable requirements as specified for the joint. Size and shape of operating nut, cap nuts, and threads on hose and pumper connections shall be as specified in AWWA C502 or AWWA C503 or UL 246 . Hydrants indicated as "traffic type," shall have frangible sections as mentioned in AWWA C502 breakable features as mentioned in AWWA C503. The traffic type hydrant shall have special couplings joining upper and lower sections of hydrant barrel and upper and lower sections of hydrant stem and shall be designed to have the special couplings break from a force not less than that which would be imposed by a moving vehicle; hydrant shall operate properly under normal conditions.

b. Flush-Type Fire Hydrants: Hydrants shall conform to the applicable requirements of AWWA C502, except that they shall be of a design that will permit placement of hydrant below surface of pavement. Hydrants shall have 150 mm (6 inch) inlet, 108 mm (4 1/4 inch) minimum valve opening, one 115 mm (4 1/2) pumper connection, and one 65 mm (2 1/2 inch) hose connection. Hose and pumper connections and operating nuts shall be readily accessible, and enclosed in a cast iron box with top flush with pavement and having cast-iron cover with flush lifting handle. Inlet shall have mechanical-joint or push-on joint end , except where flanged end is indicated. Size and shape of operating nut and cap nuts and threads on hose and pumper connections shall be as specified in AWWA C502 .

2.1.2.8 Indicator Posts

UL 789. Provide for gate valves where indicated.

2.1.2.9 Valve Boxes

Provide a valve box for each gate valve on buried piping , except where indicator post is shown. Valve boxes shall be of cast iron or precast concrete of a size suitable for the valve on which it is to be used and shall be adjustable. Cast-iron boxes shall have a minimum cover and wall thickness of 5 mm (3/16 inch). Provide a round head. Cast the word "WATER" on the lid. The least diameter of the shaft of the box shall be 135 mm (5 1/4 inches). . Cast-iron box shall have a heavy coat of bituminous paint.

2.1.2.10 Valve Pits

Valve pits shall be constructed at locations indicated or as required above and in accordance with the details shown.

2.1.2.11 Turbine Type Meters

Turbine type meters shall conform to AWWA C701 Class I or Class II. The main casing shall be bronze or cast iron protected by corrosion resistant coating with stainless steel external fasteners. Registers shall be straight-reading type, shall be permanently sealed or open and shall read in cubic meters (U.S. Gallons or cubic feet). Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct reading remote register designed in accordance with AWWA C706 or an encoder type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C701.

2.1.2.12 Propeller Type Meters

Propeller type meters shall conform to AWWA C704. Registers shall be straight-reading type, shall be permanently sealed open and shall read in cubic meters (U.S. gallons or cubic feet). Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct-reading remote register designed in accordance with AWWA C706 or an encoder-type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C703.

2.1.2.13 Meter Vaults

Large meters shall be installed in reinforced concrete vaults in accordance with the details shown on the drawings.

2.1.2.14 Sleeve-Type Mechanical Couplings

Couplings shall be designed to couple plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling shall consist of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. The middle ring and the follower rings shall be true circular sections free from irregularities, flat spots, and surface defects; the design shall provide for confinement and compression of the gaskets. For ductile iron and PVC plastic pipe, the middle ring shall be of cast-iron or steel; and the follower rings shall be of malleable or ductile iron. For steel piping, the middle ring shall be of steel and the follower rings shall be of steel or malleable iron. Cast iron, ASTM A48/A48M or KS D 4301 not less than Class 25. Malleable and ductile iron shall, conform to ASTM A47/A47M and ASTM A536, respectively. Steel shall have a strength not less than that of the pipe. Gaskets shall be designed for resistance to set after installation and shall meet the applicable requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Bolts shall be track-head type, ASTM A307, Grade A, with nuts, ASTM A563M (ASTM A563), Grade A; or round-head square-neck type bolts, ASME B18.5.2.1M and ASME B18.5.2.2M with hex nuts, ASME B18.2.2 or KS B 1012. Bolts shall be 16 mm (5/8 inch) in diameter; minimum number of bolts for each coupling shall be 3 for 80 mm (3 inch) pipe, 4 for 100 mm (4 inch) pipe, 5 for 150 mm (6 inch) pipe, 6 for 200 mm (8 inch) pipe, 7 for 250 mm (10 inch) pipe, 8 for 300 mm (12 inch) and 350 mm (14 inch) pipe, 9 for 400 mm (16 inch) pipe, 10 for 450 mm (18 inch) pipe, 12 for 500 mm (20 inch) pipe, 13 for 550 mm (22 inch), and 14 for 600 mm (24 inch) pipe. Bolt holes in follower rings shall be of a shape to hold fast the necks of the bolts used. Mechanically coupled joints using a sleeve-type mechanical coupling shall not be used as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Mechanical couplings shall provide a tight flexible joint under all reasonable conditions, such as pipe movements caused by expansion, contraction, slight setting or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Couplings shall be of strength not less than the adjoining pipeline.

2.1.2.15 Bonded Joints

Where indicated , a metallic bond shall be provided at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of ferrous metallic piping to effect continuous conductivity. The bond wire shall be Size 1/0 copper conductor suitable for direct burial shaped to stand clear of the joint. The bond shall be of the thermal weld type.

2.1.2.16 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 2.5 mm (0.10 inch) in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.

2.2 WATER SERVICE LINE MATERIALS

2.2.1 Piping Materials

2.2.1.1 Copper Pipe and Associated Fittings

Pipe, ASTM B42, regular, threaded ends. Fittings shall be brass or bronze, ASME B16.15, 825 kPa (125 psi).

2.2.1.2 Copper Tubing and Associated Fittings

Tubing, ASTM B88M or KS D 5301, Type K. Fittings for solder-type joint, ASME B16.18 or ASME B16.22; fittings for compression-type joint, ASME B16.26, flared tube type.

2.2.1.3 Plastic Piping

Plastic pipe and fittings shall bear the seal of the National Sanitation Foundation (NSF) for potable water service. Plastic pipe and fittings shall be supplied from the same manufacturer.

a. Polyvinyl Chloride (PVC) Plastic Piping with Screw Joints: ASTM D1785, Schedule 40; or ASTM D2241, with SDR as necessary to provide 1000 kPa (150 psi) minimum pressure rating. Fittings, ASTM D2466 or ASTM D2467. Pipe and fittings shall be of the same PVC plastic material and shall be one of the following pipe/fitting combinations, as marked on the pipe and fitting, respectively: PVC 2120/PVC II; PVC 2116/PVC II. Solvent cement for jointing, ASTM D2564. Pipe couplings, when used shall be tested as required by ASTM D2464.

b. Polyvinyl Chloride (PVC) Plastic Piping with Elastomeric-Gasket Joints:

   Pipe shall conform to dimensional requirements of ASTM D1785 Schedule 40, with joints meeting the requirements of 1.03 MPa (150 psi)i working pressure, 1.38 MPa (200 psi) hydrostatic test pressure, unless otherwise shown or specified.

c. Polyvinyl Chloride (PVC) Plastic Piping with Solvent Cement Joints:

Pipe shall conform to dimensional requirements of ASTM D1785 or ASTM D2241 with joints meeting the requirements of 1.03 MPa(150 psi) working pressure and 1.38 MPa (200 psi) hydrostatic test pressure.

d. Polyethylene (PE) Plastic Pipe: Pipe tubing, and heat fusion fitting shall conform to AWWA C901.

e. Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe: AWWA C909, plain end or gasket bell end, Pressure Class 150 with cast iron pipe equivalent outside diameter.

2.2.1.4 Steel Piping and Associated Fittings

Pipe, ASTM A53/A53M or KS D 3507, Standard Weight, zinc-coated. Fittings, ASME B16.4, Class 125, zinc coated; or ASME B16.3 or KS B 1533, Class 150, zinc coated, threaded.

2.2.1.5 Protective Materials for Steel Pipe Less than 80 mm (3 inches) 3 Inches

Protective materials for steel pipe, except as otherwise specified, shall be mechanically applied in a factory or plant especially equipped for the purpose. The materials shall, unless otherwise indicated on the drawings, consist of the following for the indicated pipe material and size:

Pipe and fittings less than 80 mm (3 inches) in diameter shall be thoroughly cleaned of foreign material by wire brushing and solvent cleaning, and then given 1 coat of coal-tar primer and 2 coats of coal-tar enamel conforming to AWWA C203 or KS D 8307; threaded ends of pipe and fittings shall be adequately protected prior to coating.

2.2.1.6 Ductile-Iron Piping

Comply with "Ductile-Iron Piping" subparagraph under paragraph "Water Distribution Main Materials."

2.2.1.7 Insulating Joints

Joints between pipes of dissimilar metals shall have a rubber-gasketed or other suitable approved type of insulating joint or dielectric coupling which will effectively prevent metal-to-metal contact between adjacent sections of piping.

2.2.2 Water Service Line Appurtenances

2.2.2.1 Corporation Stops

Ground key type; bronze, ASTM B61 or ASTM B62; and suitable for the working pressure of the system. Ends shall be suitable for solder-joint, or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.

2.2.2.2 Curb or Service Stops

Ground key, round way, inverted key type; made of bronze, ASTM B61 or ASTM B62; and suitable for the working pressure of the system. Ends shall be as appropriate for connection to the service piping. Arrow shall be cast into body of the curb or service stop indicating direction of flow.

2.2.2.3 Service Clamps

Service clamps used for repairing damaged cast-iron, steel, PVC or asbestos-cement pipe shall have a pressure rating not less than that of the pipe to be connected and shall be either the single or double flattened strap type. Clamps shall have a galvanized malleable-iron body with cadmium plated straps and nuts. Clamps shall have a rubber gasket cemented to the body.

2.2.2.4 Goosenecks

Type K copper tubing. Joint ends for goosenecks shall be appropriate for connecting to corporation stop and service line. Where multiple gooseneck connections are required for an individual service, goosenecks shall be connected to the service line through a suitable approved brass or bronze branch connection; the total clear area of the branches shall be at least equal to the clear area of the service line. Length of goosenecks shall be in accordance with standard practice.

2.2.2.5 Dielectric Fittings

Dielectric fittings shall be installed between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains. Dielectric fittings shall prevent metal-to-metal contact of dissimilar metallic piping elements and shall be suitable for the required working pressure.

2.2.2.6 Check Valves

Check valves shall be designed for a minimum working pressure of 1.03 MPa (150 psi) or as indicated. Valves shall have a clear waterway equal to the full nominal diameter of the valve. Valves shall open to permit flow when inlet pressure is greater than the discharge pressure, and shall close tightly to prevent return flow when discharge pressure exceeds inlet pressure. The size of the valve, working pressure, manufacturer's name, initials, or trademark shall be cast on the body of each valve. Valves 50 mm (2 inches) and larger shall be outside lever and spring or outside lever and weight type.

Valves 50 mm (2 inches) and smaller shall be all bronze designed for screwed fittings, and shall conform to MSS SP-80, Class 150, Types 3 and 4 or KS B 2301 as suitable for the application.

2.2.2.7 Gate Valves Size 80 mm (3 inches) and Larger on Buried Piping

Gate valves 80 mm (3 inch) size and larger on buried piping AWWA C500 or UL 262 and of one manufacturer. Valves, AWWA C500, nonrising stem type with double-disc gates. Valves, UL 262, inside-screw type with operating nut, split wedge or double disc type gate, and designed for a hydraulic working pressure of 1200 kPa (175 psi). Materials for UL 262 valves conforming to the reference standards specified in AWWA C500. Valves shall open by counterclockwise rotation of the valve stem. Stuffing boxes shall have 0-ring stem seals and shall be bolted and constructed so as to permit easy removal of parts for repair. Valves shall have threaded ends. Valves shall have ends suitable for joining to the pipe used; push-on joint ends or mechanical-joint ends for joining to ductile-iron pipe or push-on joint ends or mechanical-joint ends for joining to PVC plastic water main pipe; gaskets and pipe ends, AWWA C111/A21.11.

2.2.2.8 Gate Valves Smaller than 80 mm (3 Inch) in Size on Buried Piping

Gate valves smaller than 80 mm (3 inches) size on Buried Piping MSS SP-80, Class 150, solid wedge, nonrising stem. Valves shall have flanged or threaded end connections, with a union on one side of the valve. Provide hand wheel operators.

2.2.2.9 Gate Valve 80 mm (3 Inch) Size and Larger

Gate valves 80 mm (3 inch) size and larger in valve chambers, valve pits and aboveground locations, AWWA C500 or UL 262 and of one make. Valves conforming to: (1) AWWA C500 shall be outside-screw-and-yoke rising-stem type with flanged ends and double-disc or solid-wedge gates shall have solid-wedge gates where indicated, and (2) UL 262 shall be outside-screw-and-yoke type, shall be designed for a hydraulic working pressure of 1200 kPa (175 psi), and shall have flanged ends and double-disc or split-wedge or solid or one-piece type gate shall have solid or one-piece type gate where indicated. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Provide valves with hand wheels that open by a counterclockwise rotation of the valve stem. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair.

2.2.2.10 Gate Valves Smaller Than 80 mm (3 inch) Size in Valve Pits

MSS SP-80, Class 150, solid wedge, inside screw, rising stem or KS B 2301. Valves shall have flanged or threaded end connections, with a union on one side of the valve and a hand wheel operator.

2.2.2.11 Curb Boxes

Provide a curb box for each curb or service stop. Curb boxes shall be of cast iron of a size suitable for the stop on which it is to be used. Provide a round head. Cast the word "WATER" on the lid. Each box shall have a heavy coat of bituminous paint.

2.2.2.12 Valve Boxes

Provide a valve box for each gate valve on buried piping. Valve boxes shall be of cast iron or precast concrete of a size suitable for the valve on which it is to be used and shall be adjustable. Provide a round head. Cast the word "WATER" on the lid. The least diameter of the shaft of the box shall be 135 mm (5.25 inches) . Cast-iron box shall have a heavy coat of bituminous paint.

2.2.2.13 Tapping Sleeves

Tapping sleeves of the sizes indicated for connection to existing main shall be the cast gray, ductile, or malleable iron, split-sleeve type with flanged or grooved outlet, and with bolts, follower rings and gaskets on each end of the sleeve. Construction shall be suitable for a maximum working pressure of 1.03 MPa (150 psi). Bolts shall have square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets shall be as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, it shall consist of an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pretorqued to 67.8 Newton meters (50 foot-pound).

2.2.2.14 Displacement Type Meters

Displacement type meters shall conform to AWWA C700. Registers shall be straight-reading and shall read in cubic meters cubic feet. Meters in sizes 13 through 25 mm (1/2 through 1 inch) shall be frost-protection design. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct reading remote register designed in accordance with AWWA C706 or an encoder type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C700.

2.2.2.15 Compound Type Meters

Compound type meters shall conform to AWWA C702 and shall be furnished with strainers. The main casing shall be bronze or cast iron protected by corrosion resistant coating with stainless steel external fasteners. The main casing shall be tapped for field testing purposes. Registers shall be straight-reading type, shall be permanently sealed or open and shall read in cubic meters (cubic feet) U.S. gallons or cubic feet. The meter shall be equipped with a coordinating register. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct reading remote register designed in accordance with AWWA C706 or an encoder type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C702.

2.2.2.16 Fire Service Type Meters

Fire service type meters shall be proportional type or turbine type conforming to AWWA C703 and shall be furnished with strainers. The main casing shall be bronze or cast iron protected by corrosion resistant coating with stainless steel external fasteners. Registers shall be straight-reading type, shall be permanently sealed or open and shall read in cubic meters (U.S. gallons or cubic feet). The meter shall be equipped with a coordinating register. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct reading remote register designed in accordance with AWWA C706 or an encoder type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C703. When turbine type main line meters are used, the meter shall be supplied with a separate check valve, as a unit.

2.2.2.17 Meter Boxes

Meter boxes shall be of cast iron, concrete, or plastic. The boxes shall be of sufficient size to completely enclose the meter and shutoff valve or service stop. Meter boxes set in paved areas subject to vehicular traffic shall be cast iron, or concrete with cast iron lid and cast iron meter reader lid. Boxes set in sidewalks, not subject to vehicular traffic, shall use concrete covers with cast iron meter reader lids or shall be concrete with cast iron lid and cast iron meter reader lid. Plastic boxes and lids shall be used in unpaved areas or grass areas not subject to vehicular traffic. Box height shall extend from invert of the meter to final grade at the meter location. The lid shall have the word "WATER" cast in it.

2.2.2.18 Disinfection

Chlorinating materials shall conform to the following:

Chlorine, Liquid: AWWA B301.

Hypochlorite, Calcium and Sodium: AWWA B300.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPELINES

3.1.1 General Requirements for Installation of Pipelines

These requirements shall apply to all pipeline installation except where specific exception is made in the "Special Requirements..." paragraphs.

3.1.1.1 Location of Water Lines

Terminate the work covered by this section at a point approximately 1.5 m 5 feet (5 feet) from the building , unless otherwise indicated. Where the location of the water line is not clearly defined by dimensions on the drawings, do not lay water line closer horizontally than 3.0 m (10 feet) from any sewer line. Where water lines cross under gravity sewer lines, encase sewer line fully in concrete for a distance of at least 3.0 m (10 feet) on each side of the crossing, unless sewer line is made of pressure pipe with rubber-gasketed joints and no joint is located within 900 mm 3 feet horizontally of the crossing. Lay water lines which cross sewer force mains and inverted siphons at least 600 mm (2 feet) above these sewer lines; when joints in the sewer line are closer than 900 mm (3 feet) horizontally from the water line, encase these joints in concrete. Do not lay water lines in the same trench with gas lines fuel lines or electric wiring. Copper tubing shall not be installed in the same trench with ferrous piping materials.Where nonferrous metallic pipe, e.g. copper tubing, cross any ferrous piping, provide a minimum vertical separation of 300 mm (12 inches) between pipes.

Where water piping is required to be installed within 1 m (3 feet)of existing structures, the water pipe shall be sleeved as required in Paragraph "Casting Pipe". The Contractor shall install the water pipe and sleeve ensuring that there will be no damage to the structures and no settlement or movement of foundations or footings.

3.1.1.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.1.1.3 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Do not under any circumstances drop or dump pipe, fittings, valves, or any other water line material into trenches. Cut pipe in a neat workmanlike manner accurately to length established at the site and work into place without springing or forcing. Replace by one of the proper length any pipe or fitting that does not allow sufficient space for proper installation of jointing material. Blocking or wedging between bells and spigots will not be permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at proper elevation and grade. Secure firm, uniform support. Wood support blocking will not be permitted. Lay pipe so that the full length of each section of pipe and each fitting will rest solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports where indicated and where necessary for fastening work into place. Make proper provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been properly made. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Depth of cover over top of pipe shall not be less than 760 mm (2 1/2 feet), or as indicated on drawings, whichever is greater.

3.1.1.4 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.1.1.5 Connections to Existing Water Lines

Make connections to existing water lines after approval is obtained and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped , except as otherwise specified, tap concrete pipe in accordance with AWWA M9 for tapping concrete pressure pipe.

3.1.1.6 Penetrations

Pipe passing through walls of valve pits and structures shall be provided with ductile-iron or Schedule 40 steel wall sleeves. Annular space between walls and sleeves shall be filled with rich cement mortar. Annular space between pipe and sleeves shall be filled with mastic.

3.1.1.7 Flanged Pipe

Flanged pipe shall only be installed above ground or with the flanges in valve pits.

3.1.2 Special Requirements for Installation of Water Mains

3.1.2.1 Installation of Ductile-Iron Piping

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" and with the requirements of AWWA C600 for pipe installation, joint assembly, valve-and-fitting installation, and thrust restraint.

a. Jointing: Make push-on joints with the gaskets and lubricant specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly. Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. Make flanged joints with the gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fitting has dimensions that do not allow the making of a proper flanged joint as specified, replace it by one of proper dimensions. Use setscrewed flanges to make flanged joints where conditions prevent the use of full-length flanged pipe and assemble in accordance with the recommendations of the setscrewed flange manufacturer. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer. Make grooved and shouldered type joints with the couplings previously specified for this type joint connecting pipe with the grooved or shouldered ends specified for this type joint; assemble in accordance with the recommendations of the coupling manufacturer. Groove pipe in the field only with approved groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint. Make insulating joints with the gaskets, sleeves, washers, bolts, and nuts previously specified for this type joint. Assemble insulating joints as specified for flanged joints, except that bolts with insulating sleeves shall be full size for the bolt holes. Ensure that there is no metal-to-metal contact between dissimilar metals after the joint has been assembled.

b. Allowable Deflection: The maximum allowable deflection shall be as given in AWWA C600. If the alignment requires deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth.

c. Pipe Anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage , except where metal harness is indicated. Thrust blocks shall be in accordance with the requirements of AWWA C600 for thrust restraint, except that size and positioning of thrust blocks shall be as indicated. Use concrete, ASTM C94/C94M or KS F 4009, having a minimum compressive strength of 15 MPa (2,500 psi) at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength. Metal harness shall be in accordance with the requirements of AWWA C600 for thrust restraint, using tie rods and clamps as shown in NFPA 24 , except as otherwise indicated.

d. Exterior Protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet, using Class A or Class C polyethylene film, in accordance with AWWA C105/A21.5.

3.1.2.2 Installation of PVC Plastic Water Main Pipe

Installation of PVC Plastic Water Main Pipe and Associated Fittings:

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines"; with the requirements of UBPPA UNI-B-3 for laying of pipe, joining PVC pipe to fittings and accessories, and setting of hydrants, valves, and fittings; and with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, Chapter 7, "Installation."

a. Jointing: Make push-on joints with the elastomeric gaskets specified for this type joint, using either elastomeric-gasket bell-end pipe or elastomeric-gasket couplings. For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel; for push-on joint connections to metal fittings, valves, and other accessories, cut spigot end of pipe off square and re-bevel pipe end to a bevel approximately the same as that on ductile-iron pipe used for the same type of joint. Use an approved lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of UBPPA UNI-B-3 for laying the pipe and the recommendations in AWWA M23, Chapter 7, "Installation," for pipe joint assembly. Assemble push-on joints for connection to fittings, valves, and other accessories in accordance with the requirements of UBPPA UNI-B-3 for joining PVC pipe to fittings and accessories and with the applicable requirements of AWWA C600 for joint assembly. Make compression-type joints/mechanical joints with the gaskets, glands, bolts, nuts, and internal stiffeners previously specified for this type joint; assemble in accordance with the requirements of UBPPA UNI-B-3 for joining PVC pipe to fittings and accessories, with the applicable requirements of AWWA C600 for joint assembly, and with the recommendations of Appendix A to AWWA C111/A21.11. Cut off spigot end of pipe for compression-type joint/mechanical-joint connections and do not re-bevel. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer using internal stiffeners as previously specified for compression-type joints.

b. Offset: Maximum offset in alignment between adjacent pipe joints shall be as recommended by the manufacturer and approved by the Contracting Officer, but shall not exceed 5 degrees.

c. Pipe Anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage , except where metal harness is indicated. Thrust blocks shall be in accordance with the requirements of UBPPA UNI-B-3 for reaction or thrust blocking and plugging of dead ends, except that size and positioning of thrust blocks shall be as indicated. Use concrete, ASTM C94/C94M or KS F 4009, having a minimum compressive strength of 15 MPa (2,500 psi) at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength. Metal harness shall be as indicated.

d. Fittings: Install in accordance with AWWA C605.

3.1.2.3 Installation of Polyethylene (PE) Plastic Piping

a. General Installation:

PE pipes shall be installed in accordance with ASTM D2774.

b. Jointing:

Jointing shall comply with ASTM D2657, Technique I-Socket Fusion or Technique II-Butt Fusion.

c. Offsets:

Maximum offset in alignment between adjacent pipe joints shall be as recommended by the manufacturer and approved by the Contracting Officer, but shall not exceed 5 degrees.

3.1.2.4 Installation of Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Piping

a. General Installation:

Install PVCO Pressure piping in accordance with AWWA C605.

b. Jointing:

As required for PVC piping.

c. Anchorage:

As required for PVC piping.

d. Offsets:

Maximum offset in alignment between adjacent pipe joints shall be as recommended by the manufacturer and approved by the Contracting Officer, but shall not exceed 5 degrees.

3.1.2.5 Installation of Reinforced and Prestressed Concrete Piping

Except as otherwise specified in the following subparagraphs, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines;" with the laying and joining requirements specified in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe"; and with the recommendations given in AWWA M9, Chapter 7, "Thrust Restraining Methods."

a. Jointing: Make joints with the gaskets specified for concrete pipe joints, using an approved lubricant recommended by the manufacturer. Assemble joints in accordance with the joining requirements specified in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe," and with the recommendations given for laying the pipe in AWWA M9, Chapter 6, "Installation by Trenching or Tunneling--Methods and Equipment."

b. Allowable Offsets: Maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets, shall be 5 degrees for reinforced concrete pipe unless a lesser amount is recommended by the manufacturer. Long radius curves in reinforced concrete pipe shall be formed by straight pipe in which spigot rings are placed on a bevel. Slight deflections may be made by straight pipe, provided that the maximum joint opening caused by such deflection does not exceed the maximum recommended by the pipe manufacturer. Short radius curves and closures shall be formed by shorter lengths of pipe, bevels, or fabricated specials specified.

c. Pipe Anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage , except where metal harness is indicated. Thrust blocks shall be in accordance with the recommendations of AWWA M9, Chapter 7, "Thrust Restraining Methods," except that size and positioning of thrust blocks shall be as indicated. Use concrete, ASTM C94/C94M, having a minimum compressive strength of 15 MPa (2,500 psi) at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength. Metal harness shall be in accordance with the recommendations for tied joints in AWWA M9, Chapter 7, "Thrust Restraining Methods."

3.1.2.6 Installation of Steel Piping

Unless otherwise specified, install pipe and fittings in accordance with AWWA M11, Chapter 12, "Transportation, Installation, and Testing."

a. Jointing: Make rubber-gasketed bell-and-spigot joints with the gaskets previously specified for this type joint, using an approved lubricant recommended by the pipe manufacturer; assemble in accordance with the recommendations of the pipe manufacturer. Make welded joints in accordance with AWWA C206 and with the recommendations given for installation of pipe in AWWA M11, Chapter 12, "Transportation, Installation, and Testing." Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer. Make flanged joints with the gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full-size bolts for the bolt holes; use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without straining the flange. When flanged pipe or fitting has dimensions that do not allow the making of a proper flanged joint as specified, replace it by one of proper dimensions. Make grooved type joints with the couplings specified for this type joint connecting pipe with roll-grooved ends or pipe with welded-on cut-grooved adapters, each with dimensions as previously specified for this type joint. Groove pipe ends in the field only with approved groove rolling equipment and groove adapters in the field only with approved groove cutting equipment; groove rolling and groove cutting equipment shall be designed especially for the purpose and produced by a manufacturer of grooved joint couplings. Obtain approval for field-cut grooves before assembling the joint. Make shouldered type joints with the couplings specified for this type joint connecting pipe with the shouldered ends specified for this type joint. Assemble grooved and shouldered type joints in accordance with the recommendations of the coupling manufacturer. Make insulating joints with the gaskets, sleeves, washers, bolts, and nuts specified for this type joint. Assemble insulating joints as specified for flanged joints, except that bolts with insulating sleeves shall be full size for the bolt holes. Ensure that there is no metal-to-metal contact between dissimilar metals after the joint has been assembled. Finish joints on piping with cement-mortar lining and on piping with cement-mortar coating as specified in Appendix on Field Joints in AWWA C205. Finish joints on piping with coal-tar enamel or coal-tar epoxy coating by cleaning, priming, coating, and wrapping with a cold-applied tape coating conforming to and applied in accordance with AWWA C209.

b. Allowable Offsets: For pipe with bell-and-spigot rubber-gasket joints, maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets shall be 5 degrees unless a lesser amount is recommended by the manufacturer. Short-radius curves and closures shall be formed by short lengths of pipe or fabricated specials specified.

c. Pipe Anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage , except where metal harness is indicated. Thrust blocks shall be in accordance with the recommendations for thrust restraint in AWWA M11, Chapter 13, "Supplementary Design Data and Details," except that size and positioning of thrust blocks shall be as indicated. Use concrete, ASTM C94/C94M or KS F 4009, having a minimum compressive strength of 15 MPa (2,500 psi) at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength. Metal harness shall be in accordance with the recommendations for joint harnesses in AWWA M11, Chapter 13, "Supplementary Design Data and Details" , except as otherwise indicated. Metal harness shall be fabricated by the pipe manufacturer and furnished with the pipe.

3.1.2.7 Installation of Valves and Hydrants

a. Installation of Valves: Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509. Install gate valves on PVC water mains in accordance with the recommendations for appurtenance installation in AWWA M23, Chapter 7, "Installation." Install check valves in accordance with the applicable requirements of AWWA C600 for valve-and-fitting installation , except as otherwise indicated. Make and assemble joints to gate valves and check valves as specified for making and assembling the same type joints between pipe and fittings.

b. Installation of Hydrants: Install hydrants , except for metal harness, in accordance with AWWA C600 for hydrant installation and as indicated. Make and assemble joints as specified for making and assembling the same type joints between pipe and fittings. Provide metal harness as specified under pipe anchorage requirements for the respective pipeline material to which hydrant is attached. Install hydrants with the 115 mm (4.5 inches) connections facing the adjacent paved surface. If there are two paved adjacent surfaces, contact the Contracting Officer for further instructions.

3.1.2.8 Installation Beneath Railroad Right-of-Way

Install piping passing under the right-of-way of a commercial railroad in accordance with the specifications for pipelines conveying nonflammable substances in Chapter 1, Part 5, of the AREMA Eng Man. For PVC plastic water main pipe, also install in accordance with the recommendations of AWWA M23 for installation of casings.

3.1.3 Installation of Water Service Piping

3.1.3.1 Location

Connect water service piping to the building service where the building service has been installed. Where building service has not been installed, terminate water service lines approximately 1.5 m (5 feet) from the building line at the points indicated; such water service lines shall be closed with plugs or caps.

3.1.3.2 Service Line Connections to Water Mains

Connect service lines to the main as indicated. Connect service lines to ductile-iron water mains in accordance with AWWA C600 for service taps. Connect service lines to PVC plastic water mains in accordance with UBPPA UNI-B-8 and the recommendations of AWWA M23, Chapter 9, "Service Connections." Connect service lines to steel water mains in accordance with the recommendations of the steel water main pipe manufacturer and with the recommendations for special and valve connections and other appurtenances in AWWA M11, Chapter 13, "Supplementary Design Data and Details."

3.1.4 Special Requirements for Installation of Water Service Piping

3.1.4.1 Installation of Metallic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" and with the applicable requirements of AWWA C600 for pipe installation, unless otherwise specified.

a. Jointing:

(1) Screwed Joints: Make screwed joints up tight with a stiff mixture of graphite and oil, inert filler and oil, or graphite compound; apply to male threads only. Threads shall be full cut; do not leave more than three threads on the pipe exposed after assembling the joint.

(2) Joints for Copper Tubing: Cut copper tubing with square ends; remove fins and burrs. Handle tubing carefully; replace dented, gouged, or otherwise damaged tubing with undamaged tubing. Make solder joints using ASTM B32, 95-5 tin-antimony or Grade Sn96 solder. Solder and flux shall contain not more than 0.2 percent lead. Before making joint, clean ends of tubing and inside of fitting or coupling with wire brush or abrasive. Apply a rosin flux to the tubing end and on recess inside of fitting or coupling. Insert tubing end into fitting or coupling for the full depth of the recess and solder. For compression joints on flared tubing, insert tubing through the coupling nut and flare tubing.

(3) Flanged Joints: Make flanged joints up tight, taking care to avoid undue strain on flanges, valves, fittings, and accessories.

b. Protection of Buried Steel Service Line Piping: Unless otherwise specified, prepare, prime, and coat exterior surface of zinc-coated steel pipe and associated fittings to be buried with hot-applied coal-tar enamel with a bonded single layer of felt wrap in accordance with AWWA C203 or KS D 8307 double felt wraps in accordance with

AWWA C203 or KS D 8307. For the felt wrap material, use fibrous-glass mat as specified in AWWA C203 or KS D 8307; use of asbestos felt will not be permitted. Use solvent wash only to remove oil, grease, and other extraneous matter from zinc-coated pipe and fittings.

3.1.4.2 Installation of Plastic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" and with the applicable requirements of ASTM D2774 and ASTM D2855, unless otherwise specified. Handle solvent cements used to join plastic piping in accordance with ASTM F402.

a. Jointing: Make solvent-cemented joints for PVC plastic piping using the solvent cement previously specified for this material; assemble joints in accordance with ASTM D2855. Make plastic pipe joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

b. Plastic Pipe Connections to Appurtenances: Connect plastic pipe service lines to corporation stops and gate valves in accordance with the recommendations of the plastic pipe manufacturer.

3.1.4.3 Service Lines for Sprinkler Supplies

Water service lines used to supply building sprinkler systems for fire protection shall be connected to the water distribution main in accordance with NFPA 24.

3.1.4.4 Location of Meters

Meters and meter boxes and Vaults shall be installed at the locations shown on the drawings. The meters shall be centered in the boxes and vaults to allow for reading and ease of removal or maintenance.

3.1.5 Disinfection

Prior to disinfection, obtain Contracting Officer approval of the proposed method for disposal of waste water from disinfection procedures. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Fill piping systems with solution containing minimum of 50 parts per million of available chlorine and allow solution to stand for minimum of 24 hours. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 and 0.5 parts per million, or the residual chlorine content of domestic water supply. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyze by a certified laboratory, and submit the results prior to the new water piping being placed into service. Disinfection of systems supplying nonpotable water is not required.

3.2 FIELD QUALITY CONTROL

3.2.1 Field Tests and Inspections

Prior to hydrostatic testing, obtain Contracting Officer approval of the proposed method for disposal of waste water from hydrostatic testing. The Contracting Officer will conduct field inspections and witness field tests specified in this section. The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing. The Contractor shall produce evidence, when required, that any item of work has been constructed in accordance with the drawings and specifications. Do not begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 5 days after placing of the concrete.

3.2.2 Testing Procedure

Test water mains and water service lines in accordance with the applicable specified standard, except for the special testing requirements given in paragraph entitled "Special Testing Requirements." Test ductile-iron water mains and water service lines in accordance with the requirements of AWWA C600 for hydrostatic testing. The amount of leakage on ductile-iron pipelines with mechanical-joints or push-on joints shall not exceed the amounts given in AWWA C600; no leakage will be allowed at joints made by any other method. Test PVC plastic water mains and water service lines made with PVC plastic water main pipe in accordance with the requirements of UBPPA UNI-B-3 for pressure and leakage tests. The amount of leakage on pipelines made of PVC plastic water main pipe shall not exceed the amounts given in UBPPA UNI-B-3, except that at joints made with sleeve-type mechanical couplings, no leakage will be allowed. Test steel water mains in accordance with applicable requirements of AWWA C600 for hydrostatic testing. The amount of leakage on steel pipelines with rubber-gasketed bell-and-spigot joints shall not exceed 1.8 liters per 24 hours per millimeter (20 gallons per 24 hours per inch) of pipe diameter per mile of pipeline; no leakage will be allowed at joints made by any other method. Repair of welded joints to stop leakage shall be done by welding only. Test water service lines in accordance with applicable requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at copper pipe joints, copper tubing joints (soldered, compression type, brazed), plastic pipe joints flanged joints and screwed joints.

3.2.3 Special Testing Requirements

For pressure test, use a hydrostatic pressure 375 kPa (50 psi) greater than the maximum working pressure of the system, except that for those portions of the system having pipe size larger than 50 mm (2 inches) in diameter, hydrostatic test pressure shall be not less than 1400 kPa (200 psi). Hold this pressure for not less than 2 hours. Prior to the pressure test, fill that portion of the pipeline being tested with water for a soaking period of not less than 24 hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

3.3 CLEANUP

Upon completion of the installation of water lines, and appurtenances, all debris and surplus materials resulting from the work shall be removed.

-- End of Section --

SECTION 33 30 00

SANITARY SEWERS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE PIPE ASSOCIATION (ACPA)

ACPA 01-102	(2000) Concrete Pipe Handbook
ACPA 01-103	(2000) Concrete Pipe Installation Manual

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2010) Manual for Railway Engineering

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2013) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2010) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C153/A21.53	(2011) Ductile-Iron Compact Fittings for Water Service
AWWA C302	(2011) Reinforced Concrete Pressure Pipe, Noncylinder Type
AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C605	(2005) Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water

AWWA C606	(2011) Grooved and Shouldered Joints
AWWA C900	(2007; Errata 2008) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA M23	(2002; 2nd Ed) Manual: PVC Pipe - Design and Installation
AWWA M9	(20083rd Ed) Manual: Concrete Pressure Pipe

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A74	(2013a) Standard Specification for Cast

	Iron Soil Pipe and Fittings
ASTM A746	(2009) Standard Specification for Ductile Iron Gravity Sewer Pipe
ASTM C12	(2009) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C14	(2011) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C14M	(2011) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C270	(2012) Standard Specification for Mortar for Unit Masonry
ASTM C361	(2011) Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
ASTM C361M	(2008) Standard Specification for Reinforced Concrete Low-Head Pressure Pipe (Metric)
ASTM C425	(2004; R 2009) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C478	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C564	(2014) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C700	(2011) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C76	(2011) Standard Specification for

	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2011) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C828	(2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C923	(2008) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C923M	(2008b) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)
ASTM C924	(2002; R 2009) Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
ASTM C924M	(2002; R 2009) Testing Concrete Pipe Sewer Liner by Low-Pressure Air Test Method (Metric)
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete
ASTM C969	(2002; R 2009) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C969M	(2002; R 2009) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C972	(2000; R 2011) Compression-Recovery of Tape Sealant
ASTM C990	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2012) Standard Specification for

	Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2235	(2004; R 2011) Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2321	(2011) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2412	(2011) Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2464	(2013) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2013a) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2680	(2001; R 2009) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping
ASTM D2751	(2005) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
ASTM D2996	(2001; E 2007; R 2007) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D2997	(2001; R 2007e1) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3034	(2008) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2007; R 2013) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

ASTM D3262	(2011) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D3350	(2010a) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3753	(2005e1) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D3840	(2010) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications
ASTM D4101	(2014) Standard Specification for Polypropylene Injection and Extrusion Materials
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D4161	(2001; R 2010) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM D624	(2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM F402	(2005) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F405	(2005) Corrugated Polyethylene (PE) Tubing and Fittings
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F714	(2010) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F794	(2003; R 2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2007) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2010) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 4307	(2009) Cast-Iron Soil Pipes and Fittings
KS D 4308	(2012) Ductile Iron Fittings
KS D 4311	(2010) Ductile Iron Pipes
KS D 4316	(2012) Mortar Lining of Ductile Iron Pipes & Fittings
KS D 8308	(2001) Zinc Hot Dip Galvanizings
KS F 2560	(2014) Chemical Admixtures for Concrete
KS F 4009	(2011) Ready-Mixed Concrete
KS F 4403	(2004) Reinforced Spun Concrete Pipes
KS F 4901	(2012) Asphalt Roofing Felts (Fiber Base, Saturated Bitumen Felts)
KS L 5201	(2013) Portland Cement
KS L 5219	(2007) Masonry Cement
KS M 3357	(2009) Plastics piping systems for hot and cold water installations - Crosslinked polyethylene(PE-X) pipes
KS M 3402	(2009) Rigid Polyvinyl Chloride Pipe Fittings for Water Works Service
KS M 3404	(2009) Unplasticized Polyvinyl Chloride Pipes for General Service
KS M 3410	(2009) Unplasticized Polyvinyl Chloride Pipes Fittings for Drain
KS M 3500	(2009) Large diameter pipes of high density polyethylene with profiled wall and smooth inside pipe surface
KS M 6613	(2007) Rubber Goods for Water Works Service

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301	(2009) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(2011) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27	Fixed Ladders

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.2 SYSTEM DESCRIPTION

1.2.1 Sanitary Sewer Gravity Pipeline

Provide mains and laterals of concrete pipe, ductile-iron pipe, acrylonitrile-butadiene-styrene (ABS) composite plastic pipe, or polyvinyl chloride (PVC) plastic pipe as indicated on drawings.. Provide building connections of concrete pipe, acrylonitrile-butadiene-styrene (ABS) solid-wall plastic pipe, or polyvinyl chloride (PVC) plastic pipe as indicated on drawings. Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 1.5 m 5 feet outside of building walls.

1.2.2 Sanitary Sewer Pressure Lines

Provide pressure lines of ductile iron pressure pipe, concrete pressure pipe, or polyvinyl chloride (PVC) plastic pressure pipe, as indicated on drawings.1.2.3   Project Description

The construction required herein shall include appurtenant structures and building sewers to points of connection with the building drains 1.5 m (5 feet) outside the building to which the sewer system is to be connected. Replace damaged material and redo unacceptable work at no additional cost to the Government. Backfilling shall be accomplished after inspection by the Contracting Officer. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe shall be stored in accordance with the manufacturer's recommendation and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Existing Conditions

SD-02 Shop Drawings

Installation Drawings
Precast concrete manhole
Metal items
Frames, covers, and gratings

SD-03 Product Data

Pipeline materials

SD-06 Test Reports

Reports

SD-07 Certificates

Portland Cement
Gaskets

SD-11 Closeout Submittals

As-Built Drawings

1.4 QUALITY ASSURANCE

1.4.1 Drawings

a. Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

b. Submit As-Built Drawings for the complete sanitary sewer system showing complete detail with all dimensions, both above and below grade, including invert elevation.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

1.5.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.1.2 Metal Items

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.5.1.3 Cement, Aggregate, and Reinforcement

Cement and other cementitious materials shall be stored in weather tight buildings, bins, or silos which will exclude moisture and contaminants and keep each material completely separated. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Aggregate shall not be stored directly on ground unless a sacrificial layer is left undisturbed. Reinforcing bars and accessories shall be stored above the ground on platforms, skids or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing shall not be used unless retested and proven to meet the specified requirements. Materials shall be capable of being accurately identified after bundles or containers are opened.

1.5.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care not to damage linings of pipe and fittings. Carry, do not drag, pipe to trench.

1.6 PROJECT/SITE CONDITIONS

Submit drawings of existing conditions, after a thorough inspection of the area in the presence of the Contracting Officer. Details shall include the environmental conditions of the site and adjacent areas. Submit copies of the records for verification before starting work.

PART 2 PRODUCTS

2.1 PIPELINE MATERIALS

Pipe shall conform to the respective specifications and other requirements specified below. Submit manufacturer's standard drawings or catalog cuts.

2.1.1 Cast-Iron Soil Piping

2.1.1.1 Cast-Iron Hub and Spigot Soil Pipe and Fittings

ASTM A74 or KS D 4307, service or extra heavy, with ASTM C564 compression-type rubber gaskets or KS F 4901.

2.1.1.2 Cast-Iron Hubless Soil Pipe and Fittings

CISPI 301 with CISPI 310 coupling joints.

2.1.2 Clay Piping

2.1.2.1 Clay Pipe and Fittings

ASTM C700, extra strength.

2.1.2.2 Clay Piping Jointing Materials

ASTM C425.

2.1.3 Concrete Gravity Sewer Piping

2.1.3.1 Concrete Gravity Pipe and Fittings

Pipe shall be nonreinforced concrete pipe conforming to ASTM C14M ASTM C14, Class 1 or 2 or reinforced concrete pipe conforming to ASTM C76M ASTM C76 or KS F 4403, as indicated on contract drawings. Circular pipe with elliptical reinforcement shall have a readily visible line at least 300 mm (12 inches) long painted or otherwise applied on the inside and outside of the pipe at each end so that when the pipe is laid in the proper position, the line will be at the center of the top of the pipe. Fittings and specials shall conform to the applicable requirements specified for the pipe and shall be of the same strength as the pipe. Cement used in manufacturing pipe and fittings shall be Type II or Type V conforming to ASTM C150/C150M or KS L 5201.

2.1.3.2 Jointing Materials for Concrete Gravity Piping

Gaskets and pipe ends for rubber gasket joint shall conform to ASTM C443M ASTM C443 or KS M 6613. Gaskets shall be suitable for use with sewage.

2.1.4 Concrete Pressure Piping

2.1.4.1 Concrete Pressure Pipe and Fittings

Pipe shall conform to AWWA C302 or to ASTM C361M ASTM C361. Pipe shall be designed for hydrostatic head of and external loading of of earth cover as indicated on contract drawings. Circular pipe with elliptical reinforcement shall have a readily visible line at least 300 mm (12 inches) long painted or otherwise applied on the inside and outside of the pipe at each end so that when the pipe is laid in the proper position, the line will be at the center of the top of the pipe. Cement used in manufacturing pipe and fittings shall be Type II or Type V, as indicated, conforming to ASTM C150/C150M. Fittings shall conform to AWWA C302.

2.1.4.2 Jointing Materials for Concrete Pressure Piping

Gaskets shall be as specified in ASTM C361M (ASTM C361) and shall be suitable for use with sewage.2.1.5 Ductile Iron Gravity Sewer Pipe and Associated Fittings

2.1.5.1 Ductile Iron Gravity Pipe and Fittings

Ductile iron pipe shall conform to ASTM A746, AWWA C151/A21.51 or KS D 4311. Fittings shall conform to AWWA C110/A21.10 or AWWA C153/A21.53 or KS D 4308. Fittings with push-on joint ends shall conform to the same requirements as fittings with mechanical-joint ends, except that the bell design shall be modified, as approved by the Contracting Officer, for push-on joint. Fittings shall have strength at least equivalent to that of the pipe. Ends of pipe and fittings shall be suitable for the joints specified hereinafter. Pipe and fittings shall have cement-mortar lining conforming to AWWA C104/A21.4, standard thickness or KS D 4316.

2.1.5.2 Ductile Iron Gravity Joints and Jointing Materials

Pipe and fittings shall have push-on joints or mechanical joints, except as otherwise specified in this paragraph. Mechanical joints only shall be used where indicated. Push-on joint pipe ends and fitting ends, gaskets, and lubricant for joint assembly shall conform to AWWA C111/A21.11 or KS D 4308. Mechanical joint requirements for pipe ends, glands, bolts and nuts, and gaskets shall conform to AWWA C111/A21.11 or KS D 4308.

2.1.6 Ductile Iron Pressure Piping

2.1.6.1 Ductile Iron Pressure Pipe and Fittings

Ductile-iron pipe shall conform to AWWA C151/A21.51, Thickness Class as indicated. Flanged pipe shall conform to AWWA C115/A21.15. Fittings shall conform to AWWA C110/A21.10 or AWWA C153/A21.53. Fittings shall have pressure rating at least equivalent to that of the pipe. Ends of pipe and fittings shall be suitable for the joints specified hereinafter. Pipe and fittings shall have cement-mortar lining conforming to AWWA C104/A21.4, standard thickness.

2.1.6.2 Ductile Iron Pressure Joints and Jointing Materials

a. Joints, general: Joints for pipe and fittings shall be push-on joints or mechanical joints except as otherwise specified in this paragraph. Joints shall be mechanical-joints where indicated. Joints shall be flanged joints where indicated. Joints made with sleeve-type mechanical coupling may be used in lieu of push-on joint. Grooved or shouldered type joints may be used in lieu of push-on joint or flanged joint, except where joint is buried.

b. Push-on joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly shall conform to AWWA C111/A21.11.

c. Mechanical joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets shall conform to AWWA C111/A21.11.

d. Flanged joints: Bolts, nuts, and gaskets for flanged connections shall be as recommended in the Appendix to AWWA C115/A21.15. Flanges for setscrew fastened flanges shall be of ductile iron, ASTM A536, Grade 65-45-12, and shall conform to the applicable requirements of ASME B16.1, Class 250. Setscrews for setscrew fastened flanges shall be 1310 MPa 190,000 psi tensile strength, heat treated, and zinc-coated steel. Gasket for setscrew fastened flanges shall conform to the applicable requirements for mechanical-joint gaskets specified in AWWA C111/A21.11. Design of setscrew fastened gasket shall provide for confinement and compression of gasket when joint to adjoining flange is made.

e. Joints made with sleeve-type mechanical couplings: Couplings shall be designed to couple plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling shall consist of one middle ring flared or beveled at each end to provide a gasket seat, two follower rings, two resilient tapered rubber gaskets, and bolts and nuts to draw the follower rings toward each other to compress the gaskets. The middle ring and the follower rings shall be true circular sections free from irregularities, flat spots, and surface defects; the design shall provide for confinement and compression of the gaskets. Middle ring shall be of cast-iron or steel, and the follower rings shall be of malleable iron or ductile iron. Cast iron shall conform to ASTM A48/A48M and shall be not less than Class 25. Malleable iron shall conform to ASTM A47/A47M. Ductile iron shall conform to ASTM A536. Steel shall have a strength not less than that of the pipe. Gaskets shall be designed for long life and resistance to set after installation and shall meet the applicable requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Bolts shall be track-head type; bolts and nuts shall be either of the following: bolts conforming to the tensile requirements of ASTM A307, Grade A, with nuts conforming to the tensile requirements of ASTM A563M ASTM A563, Grade A; or round-head square-neck type bolts conforming to ASME B18.5.2.1M and ASME B18.5.2.2M with hex nuts conforming to ASME B18.2.2. Bolts shall be 16 mm 5/8 inch in diameter; Bolts shall be 16 mm (5/8 inch) in diameter; minimum number of bolts for each coupling shall be 3 for 80 mm (3 inch) pipe, 4 for 100 mm (4 inch) pipe, 5 for 150 mm (6 inch) pipe, 6 for 200 mm (8 inch) pipe, 7 for 250 mm (10 inch) pipe, 8 for 300 mm (12 inch) and 350 mm (14 inch) pipe, 9 for 400 mm (16 inch) pipe, 10 for 450 mm (18 inch) pipe, 12 for 500 mm (20 inch) pipe, 13 for 550 mm (22 inch), and 14 for 600 mm (24 inch) pipe. Bolt holes in follower rings shall be of a shape to hold fast the necks of the bolts used. Sleeve-type mechanical couplings shall not be used as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint.

f. Grooved and shouldered Type Joints: Grooved and shouldered pipe ends and couplings shall conform to AWWA C606. Joint dimensions shall be as specified in AWWA C606 for rigid joints.2.1.7 ABS Composite Plastic Piping

2.1.7.1 ABS Composite Plastic Pipe and Fittings

ASTM D2680 or KS M 3404.

2.1.7.2 Jointing Materials for ABS Composite Plastic Piping

Solvent cement and primer shall conform to ASTM D2680 or KS M 3404.

2.1.8 ABS Solid-Wall Plastic Piping

2.1.8.1 ABS Solid-Wall Plastic Pipe and Fittings

ASTM D2751, SDR 35, with ends suitable for either solvent cement joints or elastomer joints.

2.1.8.2 ABS Solid-Wall Plastic Joints and Jointing Materials

Solvent cement for solvent cement joints shall conform to ASTM D2235. Elastomeric joints shall conform to ASTM D3212 or KS M 3402. Gaskets for elastomeric joints shall conform to ASTM F477.

2.1.9 PVC Plastic Gravity Sewer Piping

2.1.9.1 PVC Plastic Gravity Pipe and Fittings

ASTM D3034, SDR 35, ASTM F949, KS M 3404 VG1, or KS M 3410 with ends suitable for elastomeric gasket joints. ASTM F794, Series 46, for ribbed sewer pipe with smooth interior, size 200 mm (8 inch) through 1200 mm (48 inch) diameters.

2.1.9.2 PVC Plastic Gravity Joints and Jointing Material

Joints shall conform to ASTM D3212 or KS M 3402. Gaskets shall conform to ASTM F477.

2.1.10 PVC Plastic Pressure Pipe and Associated Fittings

2.1.10.1 PVC Plastic Pressure Pipe and Fittings

a. Pipe and Fittings Less Than 100 mm (4 inch) Diameter: Pipe, couplings and fittings shall be manufactured of materials conforming to ASTM D1784, Class 12454B.

   (1) Screw-Joint: Pipe shall conform to dimensional requirements of ASTM D1785, Schedule 80, with joints meeting requirements of 1.03 Mpa (150 psi) working pressure, 1.38 Mpa (200 psi) hydrostatic test pressure, unless otherwise shown or specified. Fittings for threaded pipe shall conform to requirements of ASTM D2464, threaded to conform to the requirements of ASME B1.20.2M ASME B1.20.1 for use with Schedule 80 pipe and fittings. Pipe couplings when used, shall be tested as required by ASTM D2464.

   (2) Push-On Joint: ASTM D3139, with ASTM F477 gaskets. Fittings for push-on joints shall be iron conforming to AWWA C110/A21.10 or AWWA C111/A21.11. Iron fittings and specials shall shall be cement-mortar lined (standard thickness) in accordance with AWWA C104/A21.4.

   (3) Solvent Cement Joint: Pipe shall conform to dimensional requirements of ASTM D1785 or ASTM D2241 with joints meeting the requirements of 1.03 Mpa (150 psi) working pressure and 1.38 Mpa (200 psi) hydrostatic test pressure. Fittings for solvent cement jointing shall conform to ASTM D2466 or ASTM D2467.

b. Pipe and Fittings 100 mm (4 inch) Diameter to 300 mm (12 inch): Pipe shall conform to AWWA C900 and shall be plain end or gasket bell end, Pressure Class 150 (DR 18), with cast-iron-pipe-equivalent OD. Fittings shall be gray-iron or ductile-iron conforming to AWWA C110/A21.10 or AWWA C153/A21.53 and shall have cement-mortar lining conforming to AWWA C104/A21.4, standard thickness. Fittings with push-on joint ends shall conform to the same requirements as fittings with mechanical-joint ends, except that bell design shall be modified, as approved, for push-on joint suitable for use with the PVC plastic pressure pipe specified in this paragraph.

2.1.10.2 PVC Plastic Pressure Joints and Jointing Material

Joints for pipe, 100 mm (4 inch) to 300 mm (12 inch) diameter, shall be push-on joints as specified in ASTM D3139. Joints between pipe and fittings shall be push-on joints as specified in ASTM D3139 or shall be compression-type joints/mechanical-joints as respectively specified in ASTM D3139 and AWWA C111/A21.11. Each joint connection shall be provided with an elastomeric gasket suitable for the bell or coupling with which it is to be used. Gaskets for push-on joints for pipe shall conform to ASTM F477. Gaskets for push-on joints and compression-type joints/mechanical-joints for joint connections between pipe and fittings shall be as specified in AWWA C111/A21.11, respectively, for push-on joints and mechanical-joints.

2.1.11 High Density Polyethylene Pipe

ASTM F894, Class 63 or KS M 3500, size 450 mm (18 inch) through 3000 mm (120 inch). ASTM F714, size 100 mm (4 inch) through 1200 mm (48 inch). The polyethylene shall be certified by the resin producer as meeting the requirements of ASTM D3350, cell Class 334433C or KS M 3357. The pipe stiffness shall be greater than or equal to 1170/D for cohesionless material pipe trench backfills. Fittings for High Density Polyethylene Pipe: ASTM F894 or KS M 3500. Joints for high density polyethylene pipe: Rubber gasket joints shall conform to ASTM C443M ASTM C443 or KS M 6613.

2.1.12 Reinforced Plastic Mortar Pipe (RPMP)

Reinforced plastic mortar pipe shall be produced be in accordance with ASTM D3262 and shall have an outside diameter equal to ductile iron pipe dimensions from 450 mm (18 inch) to 1200 mm (48 inch). The inner surface of the pipe shall have a smooth uniform continuous resin-rich surface liner. The minimum pipe stiffness shall be 248 kPa (36 psi). RPMP shall be in accordance with ASTM D3262. Fittings for RPMP: ASTM D3840. Joints for RPMP: Bell and spigot gasket coupling utilizing an elastomeric gasket in accordance with ASTM D4161 and ASTM F477.

2.1.13 Reinforced Thermosetting Resin Pipe (RTRP)

RTRP pipe: ASTM D3262. Fittings for RTRP: ASTM D3262. Joints for RTRP: Bell and spigot type utilizing an elastomeric gasket in accordance with ASTM F477.

2.1.13.1 Filament Wound RTRP-I

RTRP-I shall conform to ASTM D2996, except pipe shall have an outside diameter equal to cast iron outside diameter or standard weight steel pipe. The pipe shall be suitable for a normal working pressure of 1.03 MPa (150 psi) at 22.8 degrees C (73 degrees F). The inner surface of the pipe shall have a smooth uniform continuous resin-rich surface liner conforming to ASTM D2996.

2.1.13.2 Centrifugally Cast RTRP-II

RTRP-II shall conform to ASTM D2997. Pipe shall have an outside diameter equal to standard weight steel pipe.

2.1.14 Piping Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, piping shall conform to the specifications for pipelines conveying nonflammable substances in AREMA Eng Man, except as otherwise specified in this paragraph. For casing pipe provide ductile-iron pipe in lieu of cast-iron soil pipe. Ductile-iron pipe shall conform to and have strength computed in accordance with ASTM A746, AWWA C151/A21.51, or KS D 4311.

2.2 CONCRETE MATERIALS

2.2.1 Cement Mortar

Cement mortar shall conform to ASTM C270, Type M or KS L 5219.

2.2.2 Portland Cement

Submit certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings and precast manholes. Portland cement shall conform to ASTM C150/C150M, Type IIor V for concrete used in concrete pipe, concrete pipe fittings, and manholes and type optional with the Contractor for cement used in concrete cradle, concrete encasement, and thrust blocking. Air-entraining admixture conforming to ASTM C260/C260M or KS F 2560 shall be used with Type V or KS L 5201 Class V cement.

2.2.3 Portland Cement Concrete

Portland cement concrete shall conform to ASTM C94/C94M or KS F 4009, compressive strength of 28 MPa (4000 psi) at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement shall have a compressive strength of 17 MPa (2500 psi) minimum at 28 days. Concrete in place shall be protected from freezing and moisture loss for 7 days.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Precast Concrete Manholes & Glass-Fiber-Reinforced Polyester Manholes

Precast concrete manhole risers, base sections, and tops shall conform to ASTM C478MASTM C478; base and first riser shall be monolithic. Glass-Fiber-Reinforced Polyester Manholes shall conform to ASTM D3753.

2.3.2 Gaskets and Connectors

Gaskets for joints between manhole sections shall conform to ASTM C443M ASTM C443 or KS M 6613. Resilient connectors for making joints between manhole and pipes entering manhole shall conform to ASTM C923M ASTM C923 or ASTM C990M ASTM C990.

2.3.3 External Preformed Rubber Joint Seals

An external preformed rubber joint seal shall be an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" shall be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal shall be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of 1.5 mm (60 mils). Each unit shall consist of a top and bottom section and shall have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic shall be a non-hardening butyl rubber sealant and shall seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections shall cover up to two more adjusting rings. Properties and values are listed in the following tables:

Properties, Test Methods and Minimum Values for
Rubber used in Preformed Joint Seals

Physical Properties	Test Methods	EPDM	Neoprene	Butyl mastic
Tensile, kPa	ASTM D412	12,684	15,132	-
Elongation percent	ASTM D412	553	295	350
Tear Resistance, N/mm	ASTM D624 (Die B)	49	28	-

Properties, Test Methods and Minimum Values for
Rubber used in Preformed Joint Seals

Physical Properties	Test Methods	EPDM	Neoprene	Butyl mastic
Rebound, percent, 5 minutes	ASTM C972 (mod.)	-	-	11
Rebound, percent, 2 hours	ASTM C972	-	-	12

Properties, Test Methods and Minimum Values for
Rubber used in Preformed Joint Seals

Physical Properties	Test Methods	EPDM	Neoprene	Butyl mastic
Tensile, psi	ASTM D412	1840	2195	-
Elongation percent	ASTM D412	553	295	350
Tear Resistance, ppi	ASTM D624 (Die B)	280	160	-
Rebound, percent, 5 minutes	ASTM C972 (mod.)	-	-	11
Rebound, percent, 2 hours	ASTM C972	-	-	12

2.3.4 Metal Items

2.3.4.1 Frames, Covers, and Gratings for Manholes

Frames and covers shall be cast iron, ductile iron or reinforced concrete. Cast iron frames and covers shall be as indicated or shall be of type suitable for the application, circular, without vent holes. The frames and covers shall have a combined weight of not less than 181.4 kg (400 pounds). Reinforced concrete frames and covers shall be as indicated or shall conform to ASTM C478M ASTM C478. The word "Sanitary Sewer" or "S" shall be stamped or cast into covers so that it is plainly visible.

2.3.4.2 Manhole Steps

Zinc-coated steel or as indicated, conforming to 29 CFR 1910.27. As an option, plastic or rubber coating pressure-molded to the steel may be used. Plastic coating shall conform to ASTM D4101, copolymer polypropylene. Rubber shall conform to ASTM C443M ASTM C443, except shore A durometer hardness shall be 70 plus or minus 5. Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 1.2 m (4 feet deep).

2.3.4.3 Manhole Ladders

A steel ladder shall be provided where the depth of a manhole exceeds 3.6 m 12 feet. The ladder shall not be less than 406 mm (16 inches) in width, with 19 mm (3/4 inch diameter rungs spaced 305 mm (12 inches) apart. The two stringers shall be a minimum 10 mm (3/8 inch) thick and 51 mm (2 inches) wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M or KS D 8308.

2.3.4.4 Septic Tank Piping

Cast iron soil pipe and fittings.

2.3.4.5 Siphon for Septic Tank

Welded steel or close-grained cast iron free from flaws, of an approved standard design, and prompt and positive in action.

2.3.5 Sewage Absorption Field Materials

a. Pipe shall be perforated bell-and-spigot clay pipe conforming to ASTM C700, clay drain tile, perforated corrugated polyethylene tubing conforming to ASTM F405. Covering for open joints in drain tile lines shall be asphalt-treated paper or asphalt-covered fibrous glass cloth. Wire for fastening covering to tile shall be 1.2 mm (No. 18 American Wire Gage), nonferrous metal composition.

2.4 REPORTS

Submit Test Reports. Compaction and density test shall be in accordance with Section 31 00 00 EARTHWORK. Submit Inspection Reports for daily activities during the installation of the sanitary system. Information in the report shall be detailed enough to describe location of work and amount of pipe laid in place, measured in linear meters (feet).

PART 3 EXECUTION

3.1 INSTALLATION OF PIPELINES AND APPURTENANT CONSTRUCTION

3.1.1 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.1.1.1 Location

The work covered by this section shall terminate at a point approximately 1.5 m (5 feet) from the building , unless otherwise indicated. Where the location of the sewer is not clearly defined by dimensions on the drawings, do not lay sewer line closer horizontally than 3 m (10 feet) to a water main or service line. Install pressure sewer lines beneath water lines only, with the top of the sewer line being at least 0.60 m (2 feet) below bottom of water line. Where sanitary sewer lines pass above water lines, encase sewer in concrete for a distance of 3 m (10 feet) on each side of the crossing, or substitute rubber-gasketed pressure pipe for the pipe being used for the same distance. Where sanitary sewer lines pass below water lines, lay pipe so that no joint in the sewer line will be closer than 0.9 m (3 feet), horizontal distance, to the water line.

3.1.1.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.1.1.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell or groove ends in the upgrade direction. Adjust spigots in bells to give a uniform space all around. Blocking or wedging between bells and spigots or tongues and grooves will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batter boards not more than 7.50 m (25 feet) apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of plasterboards for the same purpose. Branch connections shall be made by use of regular fittings or solvent cemented saddles as approved. Saddles for ABS and PVC composite pipe shall conform to Figure 2 of ASTM D2680 or KS M 3404; saddles for ABS pipe shall comply with Table 3 of ASTM D2751; and saddles for PVC pipe shall conform to Table 4 of ASTM D3034.

3.1.1.4 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.1.2 Special Requirements

3.1.2.1 Installation of Cast Iron Soil Piping

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the recommendations of the pipe manufacturer. Make joints with the rubber gaskets specified for cast iron soil pipe joints and assemble in accordance with the recommendations of the pipe manufacturer.

3.1.2.2 Installation of Clay Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM C12 for pipe laying. Make joints with a compression joint material specified for clay pipe joints and assemble in accordance with the recommendations of the manufacturer of the pipe.

3.1.2.3 Installation of Concrete Gravity Sewer Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the provisions for rubber gasket jointing and jointing procedures of ACPA 01-103 or of ACPA 01-102, Chapter 9, "Installation, Inspection and Construction Testing." Make joints with the gaskets specified for concrete gravity sewer pipe joints. Clean and dry surfaces receiving lubricants, cements, or adhesives. Affix gaskets to pipe not more than 24 hours prior to the installation of the pipe. Protect gaskets from sun, blowing dust, and other deleterious agents at all times. Before installation of the pipe, inspect gaskets and remove and replace loose or improperly affixed gaskets. Align each pipe section with the previously installed pipe section, and pull the joint together. If, while pulling the joint, the gasket becomes loose and can be seen through the exterior joint recess when the pipe is pulled up to within 25 mm (1 inch) of closure, remove the pipe and remake the joint.

3.1.2.4 Installation of Concrete Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the laying and joining requirements specified in the guide specifications for installation of pipe given in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe."

a. Joints: Make joints with the gaskets specified for concrete pressure pipe joints, using an approved lubricant recommended by the pipe manufacturer. Assemble these joints in accordance with the joining requirements specified in the guide specifications for installation of pipe given in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe," and with the recommendations given for laying the pipe in AWWA M9, Chapter 6, "Installation by Trenching or Tunneling -- Methods and Equipment."

b. Pipe anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 13.80 MPa (2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.1.2.5 Installation of Ductile Iron Gravity Sewer Pipe

Unless otherwise specified, install pipe and associated fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of AWWA C600 for pipe installation and joint assembly.

a. Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly. Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11.

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105/A21.5, using Class Aor Class C polyethylene film.

3.1.2.6 Installation of Ductile-Iron Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of AWWA C600 for pipe installation, joint assembly, and valve-and-fitting installation.

a. Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly. Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. Make flanged joints with gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight, taking care to avoid undue strain on flanges, fittings, and other accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fittings have dimensions that do not allow the making of a proper flanged joint as specified, replace it by one of proper dimensions. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer, as approved. Make grooved and shouldered type joints with the couplings previously specified for this type joint connecting pipe with the grooved or shouldered ends specified for this type joint and assemble in accordance with the recommendations of the coupling manufacturer, as approved. Groove pipe in the field only with approved groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint.

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105/A21.5, using Class A polyethylene film, unless otherwise indicated.

c. Pipe anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 13.80 MPa (2,000 psi) at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.1.2.7 Installation of ABS Composite Plastic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the recommendations of the plastic pipe manufacturer. Make joints with the primer and solvent cement specified for this joint and assemble in accordance with the recommendations of the pipe manufacturer. Handle solvent cement in accordance with ASTM F402.

3.1.2.8 Installation of ABS Solid-Wall Plastic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the recommendations of the plastic pipe manufacturer. Make solvent cement joints with the solvent cement previously specified for this type joint. Make elastomeric joints with the gaskets specified for this type joint and assemble in accordance with the recommendations of the pipe manufacturer. Handle solvent cement in accordance with ASTM F402.

3.1.2.9 Installation of PVC Plastic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.1.2.10 Installation of PVC Plastic Pressure Pipe and Fittings

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section; with the requirements of AWWA C605 for laying of pipe, joining PVC pipe to fittings and accessories, and setting of hydrants, valves, and fittings; and with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, Chapter 7, "Installation."

a. Pipe Less Than 100 mm (4 inches) in Diameter:

(1) Threaded joints shall be made by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together. The joints shall be tightened with strap wrenches which will not damage the pipe and fittings. The joint shall be tightened no more than 2 threads past hand-tight.

(2) Push-On Joints: The ends of pipe for push-on joints shall be beveled to facilitate assembly. Pipe shall be marked to indicate when the pipe is fully seated. The gasket shall be lubricated to prevent displacement. Care shall be exercised to ensure that the gasket remains in proper position in the bell or coupling while making the joint.

(3) Solvent-weld joints shall comply with the manufacturer's instructions.

b. Pipe 100 mm (4 Inch Diameter Joints: Make push-on joints with the elastomeric gaskets specified for this type joint, using either elastomeric-gasket bell-end pipe or elastomeric-gasket couplings. For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel; for push-on joint connections to fittings, cut spigot end of pipe off square and re-bevel pipe end to a bevel approximately the same as that on ductile-iron pipe used for the same type of joint. Use an approved lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of AWWA C605 for laying the pipe and the recommendations in AWWA M23, Chapter 7, "Installation," for pipe joint assembly. Assemble push-on joints for connection to fittings in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories and with the applicable requirements of AWWA C600 for joint assembly. Make compression-type joints/mechanical-joints with the gaskets, glands, bolts, nuts, and internal stiffeners specified for this type joint and assemble in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories, with the applicable requirements of AWWA C600 for joint assembly, and with the recommendations of Appendix A to AWWA C111/A21.11. Cut off spigot end of pipe for compression-type joint/mechanical-joint connections and do not re-bevel.

c. Pipe anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 13.80 MPa (2,000 psi) at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.1.2.11 Pipeline Installation Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, install piping in accordance with the specifications for pipelines conveying nonflammable substances in AREMA Eng Man.

3.1.3 Concrete Work

Cast-in-place concrete is included in Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE. The pipe shall be supported on a concrete cradle, or encased in concrete where indicated or directed.

3.1.4 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Cast-in-place concrete work shall be in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.1.5 Miscellaneous Construction and Installation

3.1.5.1 Connecting to Existing Manholes

Pipe connections to existing manholes shall be made so that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. The connection shall be centered on the manhole. Holes for the new pipe shall be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cutting the manhole shall be done in a manner that will cause the least damage to the walls.

3.1.5.2 Metal Work

a. Workmanship and finish: Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

b. Field painting: After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.1.6 Sewage Absorption Trench Construction

Grade pipe lines uniformly downward to the outlet. Lay perforated pipe with the perforations downward. Lay drain tile with 6 mm (1/4 inch) open joints. Cover open joints of drain tile with the cover material specified so that it extends not less than 1.75 rad (100 degrees) on each side of the vertical center line of the tile. Wire covering in place.

3.1.7 Installations of Wye Branches

Cutting into piping for connections shall not be done except in special approved cases. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, the pipe shall be encased in concrete backfill or supported on a concrete cradle as directed. Concrete required because of conditions resulting from faulty construction methods or negligence shall be installed at no additional cost to the Government. The installation of wye branches in an existing sewer shall be made by a method which does not damage the integrity of the existing sewer. One acceptable method consists of removing one pipe section, breaking off the upper half of the bell of the next lower section and half of the running bell of wye section. After placing the new section, it shall be rotated so that the broken half of the bell will be at the bottom. The two joints shall then be made with joint packing and cement mortar.

3.2 FIELD QUALITY CONTROL

3.2.1 3.2.1 Field Tests and Inspections

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Perform field tests and provide labor, equipment, and incidentals required for testing, except that water and electric power needed for field tests will be furnished as set forth in Section . Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.2.2 3.2.2 Tests for Nonpressure Lines

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; it shall show a practically full circle of light through the pipeline when viewed from the adjoining end of line. When pressure piping is used in a nonpressure line for nonpressure use, test this piping as specified for nonpressure pipe.

3.2.2.1 3.2.2.1 Leakage Tests

Test lines for leakage by either infiltration tests or exfiltration tests, or by low-pressure air tests. Prior to testing for leakage, backfill trench up to at least lower half of pipe. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

a. Infiltration tests and exfiltration tests: Perform these tests for sewer lines made of the specified materials, not only concrete, in accordance with ASTM C969M (ASTM C969). Make calculations in accordance with the Appendix to ASTM C969M (ASTM C969).

b. Low-pressure air tests: Perform tests as follows:

(1) Clay pipelines: Test in accordance with ASTM C828. Allowable pressure drop shall be as given in ASTM C828. Make calculations in accordance with the Appendix to ASTM C828.

(2) Concrete pipelines: Test in accordance with ASTM C924M (ASTM C924). Allowable pressure drop shall be as given in ASTM C924M (ASTM C924). Make calculations in accordance with the Appendix to ASTM C924M (ASTM C924).

(3) Ductile-iron pipelines: Test in accordance with the applicable requirements of ASTM C924M (ASTM C924). Allowable pressure drop shall be as given in ASTM C924M (ASTM C924). Make calculations in accordance with the Appendix to ASTM C924M (ASTM C924).

(4) ABS composite plastic pipelines: Test in accordance with the applicable requirements of UBPPA UNI-B-6. Allowable pressure drop shall be as given in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

(5) PVC plastic pipelines: Test in accordance with UBPPA UNI-B-6. Allowable pressure drop shall be as given in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.2.2.2 3.2.2.2 Deflection Testing

Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to, and over, the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads determined in accordance with ASTM D2412. Deflection of pipe in the installed pipeline under external loads shall not exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

a. Pull-through device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided the device meets the applicable requirements specified in this paragraph, including those for diameter of the device, and that the mandrel has a minimum of 9 arms. Ball, cylinder, or circular sections shall conform to the following:

(1) A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.

(2) Homogeneous material throughout, shall have a density greater than 1.0 as related to water at 4 degrees C (39.2 degrees F), and shall have a surface Brinell hardness of not less than 150.

(3) Center bored and through-bolted with a 6 mm (1/4 inch) minimum diameter steel shaft having a yield strength of not less than 483 MPa (70,000 psi), with eyes or loops at each end for attaching pulling cables.

(4) Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

b. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and shall be accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved prior to use.

c. Pull-through device procedure: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions.

d. Deflection measuring device procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, replace pipe which has excessive deflection and completely retest in same manner and under same conditions.

3.2.3 3.2.3 Tests for Pressure Lines

Test pressure lines in accordance with the applicable standard specified in this paragraph, except for test pressures. For hydrostatic pressure test, use a hydrostatic pressure 345 kPa (50 psi) in excess of the maximum working pressure of the system, but not less than 690 kPa (100 psi), holding the pressure for a period of not less than one hour. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test. Test ductile-iron pressure lines in accordance with the requirements of AWWA C600 for hydrostatic testing. Leakage on ductile-iron pipelines with mechanical-joints or push-on joints shall not exceed the amounts given in AWWA C600; allow no leakage at joints made by other methods. Test concrete pressure lines in accordance with the recommendations in AWWA M9, Chapter 10, "Hydrostatic Testing and Disinfection of Mains." Leakage on concrete pipelines shall not exceed 1.88 L/24 hours per mm of pipe diameter per kilometer (20 gallons per 24 hours per inch of pipe diameter per mile) of pipeline. Test PVC plastic pressure lines in accordance with the requirements of AWWA C605 for pressure and leakage tests, using the allowable leakage given therein.

3.2.4 3.2.4 Field Tests for Concrete

Field testing requirements are covered in Section 03 30 00 CAST-IN-PLACE CONCRETE

-- End of Section --

SECTION 33 34 00

FORCE MAINS AND INVERTED SIPHONS; SEWER
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D	(2014; Errata 1-2 2014; Errata 3 2015) Specification for Pipeline Valves

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C105/A21.5	(2010) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C200	(2005) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C207	(2007) Standard for Steel Pipe Flanges for Waterworks Service-Sizes 100 mm through 3600 mm 4 in. through 144 in.
AWWA C208	(2007; Errata 2009) Standard for Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C210	(2007) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C300	(2011) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type

AWWA C301	(2007) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
AWWA C303	(2008) Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C508	(2009) Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In. (600 mm) NPS
AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C900	(2007; Errata 2008) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA C909	(2009) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 IN through 24 IN (100 mm Through 600 mm), for Water, Wastewater, and Reclaimed Water Service

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM C478	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2122	(1998; R 2010) Determining Dimensions of Thermoplastic Pipe and Fittings

ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2464	(2013) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D3035	(2014a) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D3350	(2010a) Polyethylene Plastics Pipe and Fittings Materials
ASTM D4101	(2014) Standard Specification for Polypropylene Injection and Extrusion Materials
ASTM F1483	(2005) Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1533	(2009) Screwed Type Steel Pipe Fittings
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 3626	(2003) Coated steel pipes for water services
KS D 4308	(2012) Ductile Iron Fittings
KS D 4311	(2010) Ductile Iron Pipes
KS D 8307	(2001) Coal-tar Enamel Protective Coatings for Steel Water Pipe

KS M 3357 (2009) Plastics piping systems for hot and cold water installations - Crosslinked polyethylene(PE-X) pipes

DUCTILE IRON PIPE RESEARCH ASSOCIATION (DIPRA)

DIPRA TRD (2006) Thrust Restraint Design for Ductile Iron Pipe

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-78 (2011) Cast Iron Plug Valves, Flanged and Threaded Ends

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Hydrostatic Tests.

1.3 DELIVERY, STORAGE, AND HANDLING

Do not damage pipe, fittings and accessories, and pipe coatings during delivery, handling, and storage.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

Piping for force mains less than 100 mm (4 inches) in diameter shall be galvanized steel, polyvinyl chloride (PVC) plastic, polyethylene (PE) plastic or polypropylene plastic. Piping less than 100 mm (4 inches) in diameter inside pump stations shall be galvanized steel. Piping for force mains and inverted siphons 100 mm (4 inches) in diameter and larger shall be ductile iron, steel, concrete pressure pipe, PVC plastic, or Oriented PVC PE plastic. Piping 100 mm (4 inches) in diameter and larger inside pump stations shall be ductile iron pipe with bolted flange joints. Pipe shall conform to the respective specifications and other requirements specified below.

2.1.1 Concrete Pressure Pipe

Concrete pressure pipe and fittings shall conform to AWWA C300, AWWA C301, or AWWA C303, as applicable for the service requirements, with rubber gasket joints of the type using steel bell and spigot joint rings.

2.1.2 Plastic Pipe

2.1.2.1 PE Pipe

ASTM D3350 or KS M 3357 and ASTM D3035, minimum pressure rating of 689 kPa (100 psi) at 23 degrees C (73.4 degrees F).

2.1.2.2 Polypropylene Pipe

ASTM D2122 and ASTM D4101.

2.1.2.3 PVC Pipe

a. PVC Pipe and Fittings Less Than 100 mm (4 inches) Diameter: ASTM D1785, Schedule 40, 80, or 120, or ASTM D2241, SDR 21, 26, 32.5, with screw joints, push-on joints, or solvent weld joints.

b. PVC Pipe and Fittings 100 mm (4 inches) Diameter and Larger: ASTM D2241, SDR 21, 26, 32.5, or AWWA C900, Class 100, 150, 200, with push-on joints.

2.1.2.4 Oriented Polyvinyl Chloride (PVCO) Plastic Pipe

Pipe, couplings, and fittings shall be manufactured of material conforming to ASTM D1784, Class 12454-B. Pipe shall conform to AWWA C909, Class 150, and to ASTM F1483 and shall have an outside diameter equal to cast iron outside diameter.

2.1.3 Ductile Iron Pipe

a. Ductile Iron Pipe: AWWA C151/A21.51 or KS D 4311, working pressure not less than 1034 kPa (150 psi), unless otherwise shown or specified.

b. River Crossing Pipe: AWWA C151/A21.51 or KS D 4311, minimum thickness Class 54 with joints in compliance with applicable requirements of AWWA C110/A21.10 or KS D 4308.

c. Fittings, Mechanical: AWWA C110/A21.10 or KS D 4308, rated for 1034 kPa (150 psi).

d. Fittings, Push-On: AWWA C110/A21.10 and AWWA C111/A21.11 or KS D 4308, rated for 1034 kPa (150 psi).

2.1.4 Steel Pipe

a. Steel Pipe, 150 mm (6 inches) Diameter and Larger: AWWA C200.

b. Steel Pipe Less Than 150 mm (6 inches) Diameter: ASTM A53/A53M or KS D 3562, standard weight, threaded end, galvanized.

c. Fittings, 150 mm (6 inches) Diameter and Larger: AWWA C200, fabricated in compliance with AWWA C208.

d. Fittings Less Than 150 mm (6 inches) Diameter: ASME B16.3, galvanized or KS B 1533.

2.2 JOINTS

2.2.1 PE Piping

a. Heat Fusion Joints: ASTM D2657.

b. Flanged Joints: ASME B16.1 or AWWA C207 or KS D 3626.

c. Mechanical Joints: ASME B16.1.

2.2.2 Polypropylene Piping

Heat Fusion Joints: ASTM D2657.

2.2.3 PVC Piping

a. Screw Joint Fittings: ASTM D2464, Schedule 80.

b. Push-On Joint Fittings: ASTM D3139, with ASTM F477gaskets.

c. Solvent Cement: ASTM D2564.

d. Couplings for use with plain end pipe shall have centering rings or stops to ensure the coupling is centered on the joint.

2.2.4 PVCO Pipe

Joints shall conform to ASTM D3139. Elastomeric gaskets shall conform to ASTM F477.

2.2.5 Ductile Iron Piping

a. Push-on Joints: AWWA C111/A21.11 or KS D 4308.

b. Mechanical Joints: AWWA C111/A21.11 or KS D 4308 as modified by AWWA C151/A21.51 or KS D 4311.

c. Flanged Joints: AWWA C115/A21.15 or KS D 4308.

2.2.6 Steel Piping

a. Push-on Joints: AWWA C200.

b. Mechanical Joints: AWWA C200.

c. Flanged Joints: AWWA C207 or KS D 3626.

2.3 VALVES

2.3.1 Gate Valves

Gate valves 80 mm (3 inches) and larger shall comply with AWWA C500. Valves for buried service shall be non-rising stem (NRS), 50 mm (2 inch) square nut operated with joints applicable to the pipe or installation. Buried valves shall be furnished with extension stems comprising socket, extension stem and operating nut, and shall be of an appropriate length to bring operating nut to within 150 mm (6 inches) of grade. One 1200 mm (4 foot) "T" handle valve wrench shall be furnished for each quantity of 6 buried valves. Gate valves that are exposed or installed inside shall be outside screw and yoke (OS&Y), hand wheel operated with flange ends unless otherwise indicated. Gate valve operating nuts and hand wheels shall have an arrow and the word "OPEN" cast in raised letters to indicate the direction of opening. Gate valves 350 mm (14 inches) and larger shall be equipped with gearing to reduce operating effort. Gate valves 350 mm (14 inches) and larger installed in horizontal lines in horizontal position with stems horizontal shall be equipped with bronze track, roller and scrapers to support the weight of the gate for its full length of travel.

Gate valves 350 mm (14 inches) and larger installed in vertical pipe lines with stems horizontal shall be fitted with slides to assist the travel of the gate assembly.

2.3.2 Check Valves

Provide check valves that permit free flow of sewage forward and provide a positive check against backflow. Design check valves for a minimum working pressure of 1034 kPa (150 psi) or as indicated. The body shall be iron. The manufacturer's name, initials, or trademark and also the size of the valve, working pressure, and direction of flow shall be directly cast on the body.

a. Ball Check Valves shall be iron body, shall have flanged ends, and shall be the non-slam type. Flanges shall be the Class 125 (125 pound) type complying with ASME B16.1. Ball shall be stainless steel unless otherwise specified.

b. Swing Check Valves shall comply with AWWA C508 and shall be iron body, bronze mounted, and shall have flanged ends. Flanges shall be the Class 125 (125 pound) type complying with ASME B16.1.

2.3.3 Plug Valves

Cast iron valves shall comply with MSS SP-78. Steel plug valves shall comply with API Spec 6D.

2.3.4 Pinch Valves

Pinch valves shall be double acting, jam-proof type with unobstructed streamlined flows and built-in operator. The body shall be iron with a non-rising handwheel. The sleeve shall be of pure gum rubber, neoprene, Buna-N or hypalon as required for service. The valve shall have flanged ends. Flanges shall be of the Class 125 (125 pound) type complying with ASME B16.1.

2.3.5 Air Release Valves

Air release valves shall be designed to permit release of air from an empty pipe during filling and shall be capable of discharging accumulated air in the line while the line is in operation and under pressure. Valves shall be attached by means of threaded pipe connections. Valves shall be vented to the atmosphere.

a. Manual Air Release Valves: Manual air release valves shall consist of a 80 mm (3 inch) gate valve and 80 mm (3 inch) ductile iron pipe and fittings. The valve shall be installed with its line of flow in the horizontal position.

b. Automatic Air Release Valve: Automatic air release valves shall be of the compound lever type capable of withstanding operating pressures of 1034 kPa (150 psi). The valves shall have a 13 mm (1/2 inch) outlet. The body and cover of the valve shall be of iron with a stainless steel float. All internal parts shall be stainless steel or bronze. The valve shall be specifically adapted for use with sewage. Each valve shall be complete with hose and blow-off valves to permit backflushing without dismantling the valve.

2.4 VALVE BOXES

Valve boxes shall be cast iron or concrete, except that concrete boxes may be installed only in locations not subject to vehicular traffic. Cast iron boxes shall be the extension type with slide type adjustment and with flared base. The minimum thickness of metal shall be 5 mm (3/16 inch). The box length shall be adaptable, without full extension, to the depth of cover over the pipe at the valve locations. Concrete boxes shall be the standard product of a manufacturer of precast concrete equipment. The word "SEWER" shall be cast in the cover.

2.5 VALVE VAULTS

Valve vaults shall be precast concrete units conforming to ASTM C478M (ASTM C478).

2.6 MISCELLANEOUS MATERIALS

Miscellaneous materials shall comply with the following requirements:

2.6.1 Pipe Coatings and Linings

a. Steel, interior: AWWA C203 or KS D 8307 or AWWA C210.

b. Steel, exterior, buried: AWWA C203 or KS D 8307.

c. Steel, exterior, exposed: AWWA C210.

2.6.2 Joint Lubricants

Joint lubricants shall be as recommended by the pipe manufacturer.

2.6.3 Bolts, Nuts and Glands

AWWA C111/A21.11 or KS D 4308.

2.6.4 Joint Compound

A stiff mixture of graphite and oil or inert filler and oil.

2.6.5 Joint Tape

ASTM D3308.

2.6.6 Bond Wire

Bond wire type RHW or USE, Size 1/0 AWG, neoprene jacketed copper conductor shaped to stand clear of the joint.

PART 3 EXECUTION

3.1 INSTALLATION

Pipe, pipe fittings, and appurtenances shall be installed at the locations indicated. Excavation, trenching, and backfilling shall be as specified in Section 31 00 00 EARTHWORK.

3.1.1 Adjacent Facilities

Installation of force mains and inverted siphons near adjacent facilities shall be as specified in Section 33 30 00 SANITARY SEWERS.

3.1.2 Cutting

Pipe shall be cut in a neat manner with mechanical cutters. Wheel cutters shall be used where practicable. Sharp and rough edges shall be ground smooth and loose material removed from the pipe before laying.

3.1.3 Laying

Except where otherwise authorized, pipe shall be laid with bells facing the direction of laying. Before lowering and while suspended, the pipe shall be inspected for defects. Defective material shall be rejected. Pipe shall be laid in compliance with the following:

a. Ductile Iron: AWWA C600.

b. Steel: AWWA C600.

c. Concrete: Manufacturer's instructions.

d. Polyvinyl Chloride: Manufacturer's instructions.

e. Polyethylene: ASTM D2774.

f. Polypropylene: ASTM D2774.

3.1.4 Jointing

3.1.4.1 Concrete Pressure Pipe

The manufacturer's instructions shall be followed when lubricating and installing rubber gaskets. Joints shall comply with the manufacturer's instructions. The external annular space shall be filled with cement mortar or with a portland cement-filled polyurethane loop. For pipe 600 mm (24 inch) diameter and larger, the internal annular space shall be filled with cement mortar and struck off to ensure a smooth and continuous surface between pipe sections. Pipe less than 600 mm (24 inch) diameter shall have a rope or trowelable mastic affixed to the concrete face of the bell socket before joining the sections of pipe. The mastic shall not be detrimental to the rubber gasket and shall fill the interior annular space when the pipe sections are pushed together.

3.1.4.2 Joints for PE Pipe

Heat fusion joints shall comply with the manufacturer's instructions concerning equipment, temperature, melt time, heat coat, and joining time. Flanged and mechanical joints shall be made in compliance with the manufacturer's instructions.

3.1.4.3 Joints for Polypropylene Pipe

Heat fusion joints shall comply with the manufacturer's instructions concerning equipment, temperature, melt time, heat coat, and joining time.

3.1.4.4 Joints for PVC Pipe

a. Threaded joints shall be made by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together. The joint shall be tightened with strap wrenches which will not damage the pipe and fittings. The joint shall be tightened no more than 2 threads past hand-tight.

b. Push-on joints: The ends of pipe for push-on joints shall be beveled to facilitate assembly. Pipe shall be marked to indicate when the pipe is fully seated. The gasket shall be lubricated to prevent displacement. The gasket shall remain in proper position in the bell or coupling while the joint is made.

c. Solvent-weld joints shall comply with the manufacturer's instructions.

3.1.4.5 Joints for Ductile Iron Pipe

Installation of mechanical and push-on type joints shall comply with AWWA C600 and the manufacturer's instructions. Installation of flanged joints shall comply with manufacturer's instructions.

3.1.4.6 Joints for Steel Pipe

Screw joints shall be made tight with joint tape or joint compound applied with a brush to the male threads only. Installation of mechanical joints, push-on joints, and flanged joints shall comply with the manufacturer's instructions.

3.1.5 3.1.5 Coating and Lining

Field coating of non-galvanized steel pipe shall comply with AWWA C203 or KS D 8307. The applied materials shall be tested by means of a spark-type electrical device in compliance with AWWA C203 or KS D 8307. Flaws and holidays in the coating or lining of the pipe and the pipe joints shall be repaired; the repaired areas shall be at least equal in thickness to the minimum required for the pipe.

3.1.6 PE Pipe Encasement

Encasement shall be in accordance with AWWA C105/A21.5.

3.1.7 Installation of Valves

Prior to installation, valves shall be cleaned of all foreign matter and inspected for damage. Valves shall be fully opened and closed to ensure that all parts are properly operating. Valves shall be installed with the stem in the vertical position. Valves shall be installed in valve vaults as indicated.

3.1.8 Installation of Valve Boxes

Valve boxes shall be installed over each outside gate valve, unless otherwise indicated. Valve boxes shall be centered over the valve. Fill shall be carefully tamped around each valve box to a distance of 1.2 m (4 feet) on all sides or to undisturbed trench face, if less than 1.2 m (4 feet).

3.1.9 Installation of Valve Vaults

Valve vaults shall be installed as indicated.

3.1.10 Drain Lines

Drain lines shall be installed where indicated. The drain line shall consist of a tee in the main line with a 100 mm (4 inch) diameter branch, a 100 mm (4 inch) diameter elbow, and a 100 mm (4 inch) gate valve.

3.1.11 Thrust Restraint

Thrust Restraint shall be as specified in Section 33 11 00 WATER DISTRIBUTION. Plugs, caps, tees and bends deflecting 11-1/4 degrees or more, either vertically or horizontally, shall be provided with thrust restraint. Valves shall be securely anchored or shall be provided with thrust restraints to prevent movement. Thrust restraints shall be either thrust blocks or, for ductile-iron pipes, restrained joints.

3.1.11.1 Thrust Blocks

Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 14 MPa (2000 psi) after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of thrust blocks shall be poured directly against undisturbed earth. The sides of thrust blocks not subject to thrust may be poured against forms. The area of bearing shall be as shown or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.11.2 Restrained Joints

For ductile iron pipe, restrained joints shall be designed by the Contractor or the pipe manufacturer in accordance with DIPRA TRD.

3.1.12 Grout

Grout for exterior joint protection on concrete pipes shall be a mix of 1 part portland cement, 2 parts sand, and of sufficient liquid consistency to flow into the joint recess beneath the diaper. Grout for interior joint protection shall be a mix of 1 part portland cement and 1 part sand. A polyurethane foam loop, impregnated with portland cement, may be substituted for grout for exterior joints.

3.1.13 Bonded Joints

Where indicated, a metallic bond shall be provided at each joint, including joints made with flexible couplings or rubber gaskets, of ferrous-metallic piping to effect continuous conductivity. The bond shall be of the thermal-weld type.

3.2 HYDROSTATIC TESTS

The pipeline shall be subjected to both a pressure test and a leakage test. The method proposed for disposal of waste water from hydrostatic tests shall be approved by the Contracting Officer. Testing is the responsibility of the Contractor. The test may be witnessed by the Contracting Officer. The Contracting Officer shall be notified at least 7 days in advance of equipment tests. The final test report shall be delivered to the Contracting Officer within 30 days of the test.

3.2.1 Pressure Test

After the pipe has been installed, joints completed, thrust blocks have been in place for at least five days, and the trench has been partially backfilled, leaving the joints exposed for examination, the pipe shall be filled with water to expel all air. The pipeline shall be subjected to a test pressure of 700 kPa (100 psi) or 150 percent of the working pressure, whichever is greater, for a period of at least one hour. Each valve shall be opened and closed several times during the test. The exposed pipe, joints, fitting, and valves shall be examined for leaks. Visible leaks shall be stopped or the defective pipe, fitting, joints, or valve shall be replaced.

3.2.2 Leakage Test

The leakage test may be conducted subsequent to or concurrently with the pressure test. The amount of water permitted as leakage for the line shall be placed in a sealed container attached to the supply side of the test pump. No other source of supply will be permitted to be applied to the pump or line under test. The water shall be pumped into the line by the test pump as required to maintain the specified test pressure as described for pressure test for a 2 hour period. Exhaustion of the supply or the inability to maintain the required pressure will be considered test failure. PE pipe can experience diametric expansion and pressure elongation during initial testing. The manufacturer shall be consulted prior to testing for special testing considerations. Allowable leakage shall be determined by the following I-P formula:

L = NDP/K Where:

L = Allowable leakage in gallons per hour.

N = Number of joints in length of pipeline tested.

D = Nominal diameter of the pipe in inches.

P = Square root of the test pressure in psig.

K = 7400 for pipe materials.

At the conclusion of the test, the amount of water remaining in the container shall be measured and the results recorded in the test report.

3.2.3 Retesting

If any deficiencies are revealed during any test, such deficiencies shall be corrected and the tests shall be reperformed until the results of the tests are within specified allowances, without additional cost to the Government.

-- End of Section --

SECTION 33 40 00

STORM DRAINAGE UTILITIES
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges
AASHTO M 167M/M 167	(2009) Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches
AASHTO M 190	(2004; R 2008) Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches
AASHTO M 198	(2010) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
AASHTO M 243	(1996; R 2008) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches
AASHTO M 294	(2011) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2010) Manual for Railway Engineering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings

ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A716	(2008) Standard Specification for Ductile Iron Culvert Pipe
ASTM A74	(2013a) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A742/A742M	(2003; R 2008) Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
ASTM A760/A760M	(2010) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A762/A762M	(2008) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A798/A798M	(2007) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM A807/A807M	(2002; R 2008) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM A849	(2010) Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe
ASTM A929/A929M	(2001; R 2007) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM C1103	(2003; R 2009) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C1103M	(2003; R 2009) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C139	(2011) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C14	(2011) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C1433	(2010) Standard Specification for Precast Reinforced Concrete Box Sections for

	Culverts, Storm Drains, and Sewers
ASTM C1433M	(2010) Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers (Metric)
ASTM C14M	(2011) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C270	(2012) Standard Specification for Mortar for Unit Masonry
ASTM C32	(2011) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C425	(2004; R 2009) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C444	(2003; R 2009) Perforated Concrete Pipe
ASTM C444M	(2003; R 2009) Perforated Concrete Pipe (Metric)
ASTM C478	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C506	(2011) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C506M	(2011) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C55	(2011) Concrete Brick
ASTM C564	(2014) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C62	(2010) Building Brick (Solid Masonry Units

	Made from Clay or Shale)
ASTM C655	(2011) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C76	(2011) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2011) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C828	(2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C877	(2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C877M	(2002; R 2009) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections (Metric)
ASTM C923	(2008) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C923M	(2008b) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)
ASTM C924	(2002; R 2009) Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
ASTM C924M	(2002; R 2009) Testing Concrete Pipe Sewer Liner by Low-Pressure Air Test Method (Metric)
ASTM D1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1171	(1999; R 2007) Rubber Deterioration - Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2167	(2008) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2321	(2011) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2729	(2011) Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3034	(2008) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2007; R 2013) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3350	(2010a) Polyethylene Plastics Pipe and Fittings Materials
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM F1417	(2011a) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F679	(2008) Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F714	(2010) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F794	(2003; R 2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2007) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2010) Poly(Vinyl Chloride) (PVC)

Corrugated Sewer Pipe with a Smooth Interior and Fittings

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3503	(2008) Rolled Steels for General Structure
KS D 3590	(2009) Corrugated steel pipes and sections
KS D 4301	(2006) Grey Iron Castings
KS D 4307	(2009) Cast-Iron Soil Pipes and Fittings
KS D 8308	(2001) Zinc Hot Dip Galvanizings
KS F 2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F 2347	(2007) Test Method for Density of Soil in Place by the Rubber-Balloon Method
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2538	(2005) Specification for preformed expansion joint fillers for concrete paving and structural construction
KS F 4403	(2004) Reinforced Spun Concrete Pipes
KS M 3357	(2009) Plastics piping systems for hot and cold water installations - Crosslinked polyethylene(PE-X) pipes
KS M 3402	(2009) Rigid Polyvinyl Chloride Pipe Fittings for Water Works Service
KS M 3404	(2009) Unplasticized Polyvinyl Chloride Pipes for General Service
KS M 3600	(2009) Structured-wall polyvinyl chloride(PVC) pipes for non-pressure underground drainage and sewerage - double-wall corrugated pipe and rib pipe
KS M 6613	(2007) Rubber Goods for Water Works Service
KS M ISO 4633	(2008) Rubber seals - Joint rings for water supply, drainage and sewerage pipelines - specification for materials

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MBG 531	(2009) Metal Bar Grating Manual
NAAMM MBG 532	(2009) Heavy Duty Metal Bar Grating Manual

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Placing Pipe

SD-04 Samples

Pipe for Culverts and Storm Drains

SD-07 Certificates

Resin Certification
Pipeline Testing
Hydrostatic Test on Watertight Joints
Determination of Density
Frame and Cover for Gratings

Certified copies of test reports demonstrating conformance to applicable pipe specifications, before pipe is installed. Certification on the ability of frame and cover or gratings to carry the imposed live load.

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C76M (ASTM C76), Class I, II, III, IV, or V, as indicated in contract drawings, ASTM C655, D-Load as indicated, or KS F 4403.

2.1.1.1 Reinforced Arch Culvert and Storm Drainpipe

Manufactured in accordance with and conforming to ASTM C506M (ASTM C506), Class A-II, A-IIIor A-IV, as indicated in contract drawings.

2.1.1.2 Nonreinforced Pipe

Manufactured in accordance with and conforming to ASTM C14M (ASTM C14), Class 1, 2 or 3.

2.1.2 Corrugated Steel Pipe

KS D 3590 Type SCP 1R or SCP 1RS pipe, annular or helical or ASTM A760/A760M, zinc or aluminum (Type 2) coated pipe of either:

a. Type I or II pipe , with (2-2/3 by 1/2 inch) corrugations.

b. Type IR or IIR pipe with helical 19 by 19 by 190 mm (3/4 by 3/4 by 7-1/2 inch) corrugations.

2.1.2.1 Fully Bituminous Coated

KS D 3590, type SCP 1R or SCP 1RS pipe or AASHTO M 190 Type A and ASTM A760/A760M zinc or aluminum (Type 2) coated pipe of either:

a. Type I or II pipe with annular or helical 68 by 13 mm (2-2/3 by 1/2 inch) corrugations.

b. Type IR or IIR pipe with helical 19 by 19 by 190 mm (3/4 by 3/4 by 7-1/2 inch) corrugations.

2.1.2.2 Half Bituminous Coated, Part Paved

AASHTO M 190 Type B and ASTM A760/A760M zinc or aluminum (Type 2) coated Type I or II pipe or KS D 3590 SCR 1R or SCP 1RS with annular or helical (2-2/3 by 1/2 inch) corrugations.

2.1.2.3 Fully Bituminous Coated, Part Paved

AASHTO M 190 Type C and ASTM A760/A760M zinc or aluminum (Type 2) coated Type Ior II pipe or KS D 3590 SCR 1R or SCP 1RSwith annularor helical (2-2/3 by 1/2 inch) corrugations.

2.1.2.4 Fully Bituminous Coated, Fully Paved

AASHTO M 190 Type D and ASTM A760/A760M zinc or aluminum (Type 2) coated Type Ior II pipe or KS D 3590 Type SCR 1R or SCP 1RS pipe with annularor helical (2-2/3 by 1/2 inch) corrugations.

2.1.2.5 Concrete-Lined

ASTM A760/A760M or KS D 3590 Type SCR 1R or SCP 1RS zinc coated Type I corrugated steel pipe with annularor helical 68 by 13 mm (2-2/3 by 1/2 inch) corrugations and a concrete lining in accordance with ASTM A849.

2.1.2.6 Polymer Precoated

ASTM A762/A762M corrugated steel pipe fabricated from ASTM A742/A742M Grade 250/250 (10/10) polymer precoated sheet of either:

a. Type Ior II pipe with annularor helical (2-2/3 by 1/2 inch) corrugations.

b. Type IRor IIR pipe with helical 19 by 19 by 190 mm (3/4 by 3/4 by 7-1/2 inch) corrugations.

2.1.2.7 Polymer Precoated, Part Paved

ASTM A762/A762M Type Ior II corrugated steel pipe and AASHTO M 190 Type B (modified), paved invert only, fabricated from ASTM A742/A742M Grade 250/250 (10/10) polymer precoated sheet with annularor helical 68 by 13 mm (2-2/3 by 1/2 inch) corrugations.

2.1.2.8 Polymer Precoated, Fully Paved

ASTM A762/A762M Type Ior II corrugated steel pipe and AASHTO M 190 Type D (modified), fully paved only, fabricated from ASTM A742/A742M Grade 250/250 (10/10) polymer precoated sheet with annularor helical 68 by 13 mm (2-2/3 by 1/2 inch) corrugations.

2.1.3 Structural Plate, Steel Pipe, Pipe Arches and Arches

Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M 167M/M 167. Pipe coating, when required, shall conform to the requirements of AASHTO M 190 Type A or AASHTO M 243. Thickness of plates shall be as indicated.

2.1.4 Ductile Iron Culvert Pipe

ASTM A716.

2.1.5 Cast-Iron Soil Piping

Cast-Iron Soil Pipe shall conform to ASTM A74, service-weight or KS D 4307; gaskets shall be compression-type rubber conforming to ASTM C564.

2.1.6 Perforated Piping

2.1.6.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C444M (ASTM C444), and applicable requirements of ASTM C14M (ASTM C14), Class 1, 2 or 3.

2.1.6.2 Corrugated Steel Pipe

ASTM A760/A760M, Type III, zinc-coated or KS D 3590.

2.1.6.3 PVC Pipe

ASTM D2729.

2.1.7 PVC Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, prior to installation of the pipe.

2.1.7.1 Type PSM PVC Pipe

ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454 or KS M 3404 VG1.

2.1.7.2 Profile PVC Pipe

ASTM F794, Series 46, produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454.

2.1.7.3 Smooth Wall PVC Pipe

ASTM F679 produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454.

2.1.7.4 Corrugated PVC Pipe

ASTM F949 produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454 or KS M 3600.

2.1.8 PE Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PE used to manufacture the pipe, prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350 or KS M 3357.

2.1.8.1 Smooth Wall PE Pipe

ASTM F714, maximum DR of 21 for pipes 80 to 600 mm (3 to 24 inches) in diameter and maximum DR of 26 for pipes 650 to 1200 mm 26 to 48 inches) in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

2.1.8.2 Corrugated PE Pipe

AASHTO M 294, Type S or C. For slow crack growth resistance, acceptance of resins shall be determined by using the notched constant ligament-stress (NCLS) test meeting the requirements of AASHTO M 294. Pipe walls shall have the following properties:

Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment of Inertia of Wall Section (mm to the 4th/mm)
300	3200	390
375	4000	870
450	4900	1020
600	6600	1900
750	8300	2670
900	9500	3640
1050	9900	8900
1200	10900	8900
1350	12000	13110
1500	13650	13110

Nominal Size (in.)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in)
12	1.50	0.024
15	1.91	0.053
18	2.34	0.062
24	3.14	0.116
30	3.92	0.163
36	4.50	0.222
42	4.69	0.543
48	5.15	0.543
54	5.67	0.800
60	6.45	0.800

2.1.8.3 Profile Wall PE Pipe

ASTM F894, RSC 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 334433C or KS M 3357. Pipe walls shall have the following properties:

		Minimum Moment Of Inertia of Wall Section (mm to the 4th/mm)	
Nominal Size (mm)	Minimum Wall Area (square mm/m)	Cell Class 334433C	Cell Class 335434C
450	6300	850	620
525	8800	1150	840
600	9900	1330	970
675	12500	2050	1490
750	12500	2050	1490
825	14800	2640	2160
900	17100	3310	2700

Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment Of Inertia of Wall Section (mm to the 4th/mm)	
		Cell Class 334433C	Cell Class 335434C
1050	16500	4540	3720
1200	18700	5540	4540

Nominal Size (in.)	Minimum Wall Area (square in/ft)	Minimum Moment Of Inertia of Wall Section (in to the 4th/in)	
		Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	8.08	0.202	0.165
42	7.81	0.277	0.227
48	8.82	0.338	0.277

2.2 DRAINAGE STRUCTURES

2.2.1 Flared End Sections

Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.

2.2.2 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to ASTM C1433M (ASTM C1433).

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 23.5 MPa (3400 psi) concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 4 to 7 percent when maximum size of coarse aggregate exceeds 37.5 mm (1-1/2 inches). Air content shall be determined in accordance with ASTM C231/C231M or KS F 2421. The concrete covering over steel reinforcing shall not be less than 25 mm (1 inch) thick for covers and not less than 40 mm (1-1/2 inches) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 75 mm (3 inches) between steel and ground. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752 or KS F 2538, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.3.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar . Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.3.3 Precast Concrete Segmental Blocks

Precast concrete segmental block shall conform to ASTM C139, not more than 200 mm (8 inches) thick, not less than 200 mm (8 inches) long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.3.4 Brick

Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 13 mm (1/2 inch) of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.3.5 Precast Reinforced Concrete Manholes

Conform to ASTM C478M (ASTM C478). Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structureor made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.3.6 Prefabricated Corrugated Metal Manholes

Manholes shall be of the type and design recommended by the manufacturer. Manholes shall be complete with frames and cover, or frames and gratings.

2.3.7 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame, cover, or gratings shall be cast gray iron ASTM A48/A48M Class 225B (35B); KS D 4301 Type GC 250; cast ductile iron ASTM A536 Grade 65-45-12; cast aluminum ASTM B26/B26M Alloy 356.OT6; or galvanized steel grating conforming to KS D 3503 and KS D 8308.

Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the drawings. Steel gratings shall be designed in accordance with the drawings, or NAAMM MBG 531 and NAAMM MBG 532 to meet the indicated load requirements. Edges shall be banded with bars 6 mm (1/4 inch) (1/4 inch) less in height than bearing bars for grating sizes above 19 mm (3/4 inch) (3/4 inch). Bending bars shall be flush with the top of bearing bars. Frames shall be of welded steel construction finished to match the grating. Steel frames and gratings shall be galvanized after fabrication.

2.3.8 Joints

2.3.8.1 Flexible Watertight Joints

a. Materials: Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for plastic gaskets shall conform to AASHTO M 198, and rubber-type gaskets shall conform to ASTM C443M (ASTM C443) or KS M 6613. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 1.35 m (54 inches).

b. Test Requirements: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443M (ASTM C443). Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.3.8.2 External Sealing Bands

Requirements for external sealing bands shall conform to ASTM C877M (ASTM C877).

2.3.8.3 Flexible Watertight, Gasketed Joints

a. Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 178 mm (7 inches) wide and approximately 10 mm (3/8 inch) thick, meeting the requirements of ASTM D1056, Type 2 A1, and shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171. Rubber O-ring gaskets shall be 21 mm (13/16 inch) in diameter for pipe diameters of 914 mm (36 inches) or smaller and 22 mm (7/8 inch) in diameter for larger pipe having 13 mm (1/2 inch) deep end corrugation. Rubber O-ring gaskets shall be 35 mm (1-3/8 inches) in diameter for pipe having 25 mm (1 inch) deep end corrugations. O-rings shall meet the requirements of AASHTO M 198 or ASTM C443 (ASTM C443) or KS M 6613. Flexible plastic gaskets shall conform to requirements of AASHTO M 198, Type B.

b. Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of band, and the size of angles, bolts, rods and lugs as indicated or where not indicated as specified in the applicable standards or specifications for the pipe. Exterior rivet heads in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded. Watertight joints shall be tested and shall meet the test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

2.3.8.4 PVC Plastic Pipes

Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

2.3.8.5 Smooth Wall PE Plastic Pipe

Pipe shall be joined using butt fusion method as recommended by the pipe manufacturer.

2.3.8.6 Corrugated PE Plastic Pipe

Pipe joints shall be soil, siltand water tight and shall conform to the requirements in AASHTO M 294. Water tight joints shall be made using a PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477.

2.3.8.7 Profile Wall PE Plastic Pipe

Joints shall be gasketed or thermal weld type with integral bell in accordance with ASTM F894.

2.3.8.8 Ductile Iron Pipe

Couplings and fittings shall be as recommended by the pipe manufacturer.

2.4 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds 3.66 m (12 feet). These ladders shall be not less than 406 mm (16 inches) in width, with 19 mm (3/4 inch) diameter rungs spaced 305 mm (12 inches) apart. The two stringers shall be a minimum 10 mm (3/8 inch) thick and 63 mm (2-1/2 inches) wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M.

2.5 DOWNSPOUT BOOTS

Boots used to connect exterior downspouts to the storm-drainage system shall be of gray cast iron conforming to ASTM A48/A48M, Class 30B or 35Bor KS D 4301 Type GC 200 or GC 250. Shape and size shall be as indicated.

2.6 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923M (ASTM C923) or KS M ISO 4633, Grade 40 and 50.

2.7 HYDROSTATIC TEST ON WATERTIGHT JOINTS

2.7.1 Concrete, Clay, PVC and PE Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to AASHTO M 198 or ASTM C443M (ASTM C443) or KS M 6613. Test requirements for joints in clay pipe shall conform to ASTM C425. Test requirements for joints in PVC and PE plastic pipe shall conform to ASTM D3212 or KS M 3402.

2.7.2 Corrugated Steel and Aluminum Pipe

A hydrostatic test shall be made on the watertight joint system or coupling band type proposed. The moment strength required of the joint is expressed as 15 percent of the calculated moment capacity of the pipe on a transverse section remote from the joint by the AASHTO HB-17 (Division II, Section 26). The pipe shall be supported for the hydrostatic test with the joint located at the point which develops 15 percent of the moment capacity of the pipe based on the allowable span in meters (feet) for the pipe flowing full or 54,233 Newton meters (40,000 foot-pounds), whichever is less. Performance requirements shall be met at an internal hydrostatic pressure of 69 kPa (10 psi), for a 10 minute period for both annular corrugated metal pipe and helical corrugated metal pipe with factory reformed ends.

2.8 EROSION CONTROL RIPRAP

Provide nonerodible rock not exceeding 375 mm (15 inches) in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of 200 mm (8 inches).

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus additional width indicated to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 200 mm (8 inches) or 13 mm (1/2 inch) for each .3 meters (1 foot) of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 00 00 EARTHWORK.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 100 mm (4 inch) in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 13 mm (1/2 inch) in depth per 300 mm (foot) of depth of fill, minimum depth of bedding shall be 200 mm (8 inch) up to maximum depth of 600 mm (24 inches). The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.2.2 Corrugated Metal Pipe

Bedding for corrugated metal pipe and pipe arch shall be in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Bedding for corrugated structural plate pipe shall meet requirements of ASTM A807/A807M.

3.2.3 Ductile Iron and Cast-Iron Pipe

Bedding for ductile iron and cast-iron pipe shall be as shown on the drawings.

3.2.4 Plastic Pipe

Bedding for PVC and PE pipe shall meet the requirements of ASTM D2321. Bedding, haunching, and initial backfill shall be either Class IB or II material.

3.3 PLACING PIPE

Submit printed copies of the manufacturer's recommendations for installation procedures of the material being placed, prior to installation.

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (%)
Corrugated Steel and Aluminum Alloy	5
Concrete-Lined Corrugated Steel	3
Ductile Iron Culvert	3
Plastic (PVC & HDPE)	5

Note post installation requirements of paragraph 'Deflection Testing' in PART 3 of this specification for all pipe products including deflection testing requirements for flexible pipe.

3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron and Cast-Iron Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

The manufacturer's reference lines, designating the top of the pipe, shall be within 5 degrees of a vertical plane through the longitudinal axis of the pipe, during placement. Damage to or misalignment of the pipe shall be prevented in all backfilling operations.

3.3.3 Corrugated PE Pipe

Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's recommendations.

3.3.4 Corrugated Metal Pipe and Pipe Arch

Laying shall be with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Part paved pipe shall be installed so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Fully paved steel pipe or pipe arch shall have a painted or otherwise applied label inside the pipe or pipe arch indicating sheet thickness of pipe or pipe arch. Any unprotected metal in the joints shall be coated with bituminous material as specified in AASHTO M 190 or AASHTO M 243. Interior coating shall be protected against damage from insertion or removal of struts or tie wires. Lifting lugs shall be used to facilitate moving pipe without damage to exterior or interior coatings. During transportation and installation, pipe or pipe arch and coupling bands shall be handled with care to preclude damage to the coating, paving or lining. Damaged coatings, pavings and linings shall be repaired in accordance with the manufacturer's recommendations prior to placing backfill. Pipe on which coating, paving or lining has been damaged to such an extent that satisfactory field repairs cannot be made shall be removed and replaced. Vertical elongation, where indicated, shall be accomplished by factory elongation. Suitable markings or properly placed lifting lugs shall be provided to ensure placement of factory elongated pipe in a vertical plane.

3.3.5 Structural-Plate Steel

Structural plate shall be installed in accordance with ASTM A807/A807M. Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are tightened to meet the torque requirements of 270 Newton meters (200 foot-pounds) plus or minus 68 Newton meters (50 foot-pounds). Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Power wrenches shall be checked and adjusted frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

3.3.6 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter (3 feet) apart, whichever is less.

3.3.7 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of AREMA Eng Man.

3.4 JOINTING

3.4.1 Concrete and Clay Pipe

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe

A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.

3.4.1.3 Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe

The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.

a. Diaper Bands: Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 200 mm (8 inches) apart. Wires shall be cut into lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

b. Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.

c. Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

3.4.1.4 Cement-Mortar Tongue-and-Groove Joint

The first pipe shall be bedded carefully to the established grade line with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

3.4.1.5 Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe

The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 13 mm (1/2 inch), thick and the width of the diaper band shall be at least 200 mm (8 inches). The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.

3.4.1.6 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe

Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If non-mastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.

3.4.1.7 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.4.1.8 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

3.4.2 Corrugated Metal Pipe

3.4.2.1 Field Joints

Transverse field joints shall be designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. In addition, the joints shall meet the general performance requirements described in ASTM A798/A798M. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands, bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. The space between the pipe and connecting bands shall be kept free from dirt and grit so that corrugations fit snugly. The connecting band, while being tightened, shall be tapped with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. The annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 750 mm (30 inches) or larger, shall be filled with a bituminous material after jointing. Field joints for each type of corrugated metal pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. The type, size, and sheet thickness of the band and the size of angles or lugs and bolts shall be as indicated or where not indicated, shall be as specified in the applicable standards or specifications for the pipe.

3.4.2.2 Flexible Watertight, Gasketed Joints

Installation shall be as recommended by the gasket manufacturer for use of lubricants and cements and other special installation requirements. The gasket shall be placed over one end of a section of pipe for half the width of the gasket. The other half shall be doubled over the end of the same pipe. When the adjoining section of pipe is in place, the doubled-over half of the gasket shall then be rolled over the adjoining section. Any unevenness in overlap shall be corrected so that the gasket covers the end of pipe sections equally. Connecting bands shall be centered over adjoining sections of pipe, and rods or bolts placed in position and nuts tightened. Band Tightening: The band shall be tightened evenly, even tension being kept on the rods or bolts, and the gasket; the gasket shall seat properly in the corrugations. Watertight joints shall remain uncovered for a period of time designated, and before being covered, tightness of the nuts shall be measured with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, the nut shall be retightened with a torque wrench and remain uncovered until a tight, permanent joint is assured.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.5.2 Walls and Headwalls

Construction shall be as indicated on the drawings.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1.83 m (6 feet) vertically, and shall be installed to provide at least 152 mm (6 inches) of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 150 mm (6 inches) in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of RCP or has reached an elevation of at least 300 mm (12 inches) above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 300 mm (12 inches). Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 150 mm (6 inches) in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 300 mm (12 inches) above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 4 m (12 feet), whichever is less. After the backfill has reached at least 300 mm (12 inches) above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 300 mm (12 inches). Use select granular material for this entire region of backfill for flexible pipe installations.

3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.5 Determination of Density

Testing is the responsibility of the Contractor and performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 or KS F 2312 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or KS F 2347 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING

3.8.1 Leakage Tests

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate. Low pressure air testing for concrete pipes shall conform to ASTM C924M (ASTM C924). Low pressure air testing for plastic pipe shall conform to ASTM F1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C828 or ASTM C924M (ASTM C924), after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103M (ASTM C1103). Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm (2 feet) or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 600 mm (2 feet) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 60 liters per mm in diameter per kilometer (250 gallons per inch in diameter per mile) of pipeline per day or 9 mL per mm in diameter per 100 meters (0.2 gallons per inch in diameter per 100 feet) of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished.

3.8.2 Deflection Testing

No sooner than 30 days after completion of installation and final backfill, an initial post installation inspection shall be accomplished. Clean or flush all lines prior to inspection. Perform a deflection test on entire length of installed flexible pipeline on completion of work ,adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a laser profiler or mandrel.

a. Laser Profiler Inspection: If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, remove pipe which has excessive deflection, and replace with new pipe. Initial post installation inspections of the pipe interior with laser profiling equipment shall utilize low barrel distortion video equipment for pipe sizes 1.22 m (48 inches) or less. Use a camera with lighting suitable to allow a clear picture of the entire periphery of the pipe interior. Center the camera in the pipe both vertically and horizontally and be able to pan and tilt to a 90 degree angle with the axis of the pipe rotating 360 degrees. Use equipment to move the camera through the pipe that will not obstruct the camera's view or interfere with proper documentation of the pipe's condition. The video image shall be clear, focused, and relatively free from roll static or other image distortion qualities that would prevent the reviewer from evaluating the condition of the pipe. For initial post installation inspections for pipe sizes larger than 1.22 m (48 inches), visual inspection shall be completed of the pipe interior.

b. Pull-Through Device Inspection: Pass the pull-through device through each run of pipe by pulling it by hand. If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show excess allowable deflections of the average inside diameter of pipe, remove pipe which has excessive deflection, replace with new pipe, and completely retest in same manner and under same conditions. Pull-through device: The mandrel shall be rigid, nonadjustable having a minimum of 9 fins, including pulling rings at each end, engraved with the nominal pipe size and mandrel outside diameter. The mandrel shall be 5 percent less than the certified-actual pipe diameter for Plastic Pipe, 5 percent less than the certified-actual pipe diameter for Corrugated Steel and Aluminum Alloy, 3 percent less than the certified-actual pipe diameter for Concrete-Lined Corrugated Steel and Ductile Iron Culvert provided by manufacturer. When mandrels are utilized to verify deflection of flexible pipe products, the Government will verify the mandrel OD through the use of proving rings that are manufactured with an opening that is certified to be as shown above.

c. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved by the Contracting Officer prior to use.

d. Warranty period test: Pipe found to have a deflection of greater than allowable deflection in paragraph PLACING PIPE above, just prior to end of one-year warranty period shall be replaced with new pipe and tested as specified for leakage and deflection. Inspect 100 percent of all pipe systems under the travel lanes, including curb and gutter. Random inspections of the remaining pipe system outside of the travel lanes shall represent at least 10 percent of the total pipe footage of each pipe size. Inspections shall be made, depending on the pipe size, with video camera or visual observations. In addition, for flexible pipe installations, perform deflection testing on 100 percent of all pipes under the travel lanes, including curb and gutter, with either a laser profiler or 9-fin mandrel. For flexible pipe, random deflection inspections of the pipe system outside of the travel lanes shall represent at least 10 percent of the total pipe footage of each pipe size. When mandrels are utilized to verify deflection of flexible pipe products during the final post installation inspection, the Government will verify the mandrel OD through the use of proving rings.

3.8.3 Post-Installation Inspection

One hundred percent of all reinforced concrete pipe installations shall be checked for joint separations, soil migration through the joint, cracks greater than 0.25 mm (0.01 inches), settlement and alignment. One hundred percent of all flexible pipes (HDPE, PVC, CMP) shall be checked for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

a. Replace pipes having cracks greater than 2.5 mm (0.1 inches) in width or deflection greater than 5 percent deflection. An engineer shall evaluate all pipes with cracks greater than 0.25 mm (0.01 inches) but less than 2.5 mm (0.10 inches) to determine if any remediation or repair is required. RCP with crack width less than 2.5 mm (0.10 inches) and located in a non-corrosive environment (pH 5.5) are generally acceptable. Repair or replace any pipe with crack exhibiting displacement across the crack, exhibiting bulges, creases, tears, spalls, or delamination.

b. Reports: The deflection results and finial post installation inspection report shall include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe systems, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.9 FIELD PAINTING

After installation, clean cast-iron frames, covers, gratings, and steps not buried in masonry or concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

-- End of Section --

SECTION 33 46 16

SUBDRAINAGE SYSTEM
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 190	(2004; R 2008) Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A227/A227M	(2006; R 2011) Standard Specification for Steel Wire, Cold-Drawn for Mechanical Springs
ASTM A229/A229M	(1999; R 2005) Standard Specification for Steel Wire, Oil-Tempered for Mechanical Springs
ASTM A27/A27M	(2010) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A760/A760M	(2010) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A762/A762M	(2008) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM B745/B745M	(1997; R 2005) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C139	(2011) Standard Specification for Concrete Masonry Units for Construction of Catch

	Basins and Manholes
ASTM C14	(2011) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C14M	(2011) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C4	(2004; R 2009) Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile
ASTM C412	(2011) Concrete Drain Tile
ASTM C412M	(2011) Concrete Drain Tile (Metric)
ASTM C425	(2004; R 2009) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C444	(2003; R 2009) Perforated Concrete Pipe
ASTM C444M	(2003; R 2009) Perforated Concrete Pipe (Metric)
ASTM C478	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C55	(2011) Concrete Brick
ASTM C62	(2010) Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C654	(2011) Porous Concrete Pipe
ASTM C654M	(2011) Porous Concrete Pipe (Metric)
ASTM C700	(2011) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM D1621	(2010) Compressive Properties of Rigid Cellular Plastics

ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D1777	(1996; E 2011; R 2011) Thickness of Textile Materials
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2751	(2005) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
ASTM D3034	(2008) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2007; R 2013) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3753	(2005e1) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D3786/D3786M	(2009) Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
ASTM D4355	(2007) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491	(1999a; R 2009) Water Permeability of Geotextiles by Permittivity
ASTM D4533	(2011) Trapezoid Tearing Strength of Geotextiles
ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4632	(2008) Grab Breaking Load and Elongation of Geotextiles
ASTM D4716	(2008) Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
ASTM D4751	(2012) Determining Apparent Opening Size of a Geotextile

ASTM D4833	(2007) Index Puncture Resistance of Geotextiles Geomembranes and Related Products
ASTM D4873	(2002; R 2009) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5034	(2009; R 2013) Breaking Strength and Elongation of Textile Fabrics (Grab Test)
ASTM D570	(1998; E 2010; R 2010) Standard Test Method for Water Absorption of Plastics
ASTM F405	(2005) Corrugated Polyethylene (PE) Tubing and Fittings
ASTM F667	(2012) Large Diameter Corrugated Polyethylene Pipe and Fittings
ASTM F758	(1995; R 2007e1) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F949	(2010) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM G21	(2013) Determining Resistance of Synthetic Polymeric Materials to Fungi

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3590	(2009) Corrugated steel pipes and sections
KS D 4101	(2001) Carbon steel castings
KS D 4301	(2006) Grey Iron Castings
KS D 8308	(2001) Zinc Hot Dip Galvanizings
KS D ISO 5922	(2008) Malleable iron castings
KS D ISO 8458-1	(2003) Steel wire for mechanical springs - Part 1£ºGeneral requirements
KS D ISO 8458-2	(2003) Steel wire for mechanical springs - Part 2£ºCold-drawn carbon steel wire
KS D ISO 8458-3	(2003) Steel Wire for Mechanical Springs - Part 3£ºOil-hardened and tempered wire
KS F 2322	(2000) Permeability of Saturated Soils
KS F 2421	(2006) Air Content of Fresh Concrete by Pressure Method
KS F 2538	(2005) Specification for preformed

	expansion joint fillers for concrete paving and structural construction
KS K 0350	(2006) Test method for bursting strength of cloth : Ball bursting method
KS K 0351	(2006) Determination of bursting strength and bursting distension of cloth : hydraulic method
KS K 0520	(2009) Textiles - Tension properties of fabrics - Determination of strength and elongation : Grab method
KS K 0537	(2009) Testing method for tearing strength of cloth : Trapezoid method
KS K 0743	(2009) Test method for breaking strength and elongation of geotextiles£ºGrab method
KS K 0754	(2007) Test method for apparent opening size of geotextiles - Dry method
KS L 5201	(2013) Portland Cement
KS M 3404	(2009) Unplasticized Polyvinyl Chloride Pipes for General Service
KS M 3600	(2009) Structured-wall polyvinyl chloride(PVC) pipes for non-pressure underground drainage and sewerage - double-wall corrugated pipe and rib pipe
KS M ISO 62	(2001) Plastics - Determination of water absorption
KS M ISO 844	(2002) Cellular plastics - Compression test for rigid materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Installation Plan

The Contractor shall submit an Installation Plan detailing installation procedures for the composite drains.

SD-04 Samples

Filter Fabric
Pipe for Subdrains

SD-06 Test Reports

Product Certification

Copies of certified Manufacturer's laboratory test data.

SD-07 Certificates

Filter Fabric
Pipe for Subdrains

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Inspect materials delivered to site for damage; unload, and store with minimum handling. Do not store materials directly on the ground. The inside of pipes and fittings shall be free of dirt and debris. Keep, during shipment and storage, filter fabric wrapped in burlap or similar heavy duty protective covering. The storage area shall protect the fabric from mud, soil, dust, and debris. Filter fabric materials that are not to be installed immediately shall not be stored in direct sunlight. Install plastic pipe within 6 months from the date of manufacture unless otherwise approved.

1.3.2 Handling

Handle materials in such a manner as to ensure delivery to the trench in sound undamaged condition. Pipe shall be carried and not dragged to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR SUBDRAINS

Submit samples of pipe, and pipe fittings, before starting the work. Pipe for subdrains shall be of the types and sizes indicated. Submit certifications from the manufacturers attesting that materials meet specification requirements. Certificates are required for drain pipe, drain tile, and fittings.

2.1.1 Concrete Pipe

Class 1, 2, or 3 as indicated and conform to ASTM C14M (ASTM C14) using ASTM C150/C150M portland cement Type IIorV or KS L 5201, Class II or V.

2.1.2 Clay and Perforated Clay Pipe

2.1.2.1 Clay Pipe

Clay pipe shall be either standard or extra strength as indicated and shall conform to ASTM C700.

2.1.2.2 Perforated Clay Pipe

Perforated clay pipe shall be either standard or extra strength as indicated and shall conform to ASTM C700. Plain-end pipe conforming to the strength and perforation requirements of ASTM C700 will also be acceptable if provided with spring wire clips of approved type to maintain a taut but elastic joint between the sections of pipe when laid. Clips shall be constructed of not smaller than No. 9 hard-drawn or oil-tempered steel wire conforming to ASTM A227/A227M or KS D ISO 8458-1 and KS D ISO 8458-2 or ASTM A229/A229M or KS D ISO 8458-1 and KS D ISO 8458-3, and shall be coated with an approved rust preventive coating. Wire clips shall withstand 25 cycles of alternate loading and unloading using a stressing force of 556 N (125 pounds). The permanent set resulting from this test shall be less than 5 percent, based on the original length of the fastener. Compression joints conforming to ASTM C425 will also be acceptable.

2.1.3 Perforated Concrete Pipe

Conform to ASTM C444M (ASTM C444), Type IorII perforations and to ASTM C14M (ASTM C14), Class 1, 2, or 3 as indicated.

2.1.4 Perforated Corrugated Steel Pipe

Perforated corrugated steel pipe shall conform to ASTM A760/A760M, Type III or KS D 3590. Sheet thickness of pipe shall be as indicated.

2.1.5 Perforated Corrugated Steel, Fully Bitumin. Coated

Perforated corrugated steel pipe, fully bituminous coated, shall conform to ASTM A760/A760M, Type III or KS D 3590, with a coating conforming to AASHTO M 190, Type A. Sheet thickness of pipe shall be as indicated.

2.1.6 Drain Tile

Clay drain tile shall conform to ASTM C4 standard, extra quality or heavy duty as indicated. Concrete drain tile shall conform to ASTM C412M (ASTM C412) standard, extra, heavy duty extra, or special quality as indicated.

2.1.7 Porous Concrete Pipe

Conform to ASTM C654M (ASTM C654), standard or extra strength as indicated and using ASTM C150/C150M portland cement Type IIorV or KS L 5201, Class II or V.

2.1.8 Perforated Corrugated Aluminum Alloy Pipe

Perforated corrugated aluminum alloy pipe shall conform to ASTM B745/B745M, Type III, Class 1or 2. Sheet thickness of pipe shall be as indicated.

2.1.9 Perforated Corrugated Aluminum Alloy Pipe, Fully Bituminous Coated

Perforated corrugated aluminum alloy pipe, fully bituminous coated shall conform to ASTM B745/B745M, Type III, Class 1 or 2 with a bituminous coating conforming to AASHTO M 190, Type A.

2.1.10 Precoated Corrugated Steel Pipe

Precoated corrugated steel pipe shall conform to ASTM A762/A762M, Type III.

2.1.11 Plastic Pipe

Plastic pipe shall contain ultraviolet inhibitor to provide protection from exposure to direct sunlight.

2.1.11.1 Acrylonitrile-Butadiene-Styrene (ABS)

Acrylonitrile-butadiene-styrene (ABS) piping and fittings shall conform to ASTM D2751, with maximum SDR of 35.

2.1.11.2 Polyvinyl Chloride (PVC) and Fittings

Polyvinyl chloride (PVC) pipe and fittings shall conform to ASTM D3034, ASTM F949 or KS M 3600, ASTM F758, Type PS 46 or KS M 3404, VG1.

2.1.11.3 Corrugated Polyethylene (PE) and Fittings

Use ASTM F405 for pipes 80 to 150 mm (3 to 6 inches) in diameter, inclusive, ASTM F667 for pipes 200 to 600 mm (8 to 24 inches) in diameter. Fittings shall be manufacturer's standard type and shall conform to the indicated specification.

2.1.11.4 Pipe Perforations

Water inlet area shall be a minimum of 1,058.4 mm squared per linear meter (0.5 square inch per linear foot). Manufacturer's standard perforated pipe which essentially meets these requirements may be substituted with prior approval of the Contracting Officer.

a. Circular Perforations in Plastic Pipe: Circular holes shall be cleanly cut not more than 9.5 mm (3/8 inch) or less than 4.8 mm (3/16 inch) in diameter and arranged in rows parallel to the longitudinal axis of the pipe. Perforations shall be approximately 76.2 mm (3 inches) center-to-center along rows. The rows shall be approximately 38.1 mm (1-1/2 inches) apart and arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows. The rows shall be spaced over not more than 155 degrees of circumference. The spigot or tongue end of the pipe shall not be perforated for a length equal to the depth of the socket, and perforations shall continue at uniform spacing over the entire length of the pipe.

b. Slotted Perforations in Plastic Pipe: Circumferential slots shall be cleanly cut so as not to restrict the inflow of water and uniformly spaced along the length and circumference of the tubing. Width of slots shall not exceed 3.2 mm (1/8 inch) nor be less than 0.8 mm (1/32 inch). The length of individual slots shall not exceed 31.75 mm (1-1/4 inches) on 80 mm (3 inch) diameter tubing, 10 percent of the tubing inside nominal circumference on 100 to 200 mm (4 to 8 inch) diameter tubing, and 63.5 mm (2-1/2 inches) on 250 mm (10 inch) diameter tubing. Rows of slots shall be symmetrically spaced so that they are fully contained in 2 quadrants of the pipe. Slots shall be centered in the valleys of the corrugations of profile wall pipe.

2.2 FILTER FABRIC

Filter fabric shall be a pervious sheet of polyester, nylon, or polypropylene filaments woven or otherwise formed into a uniform pattern with distinct and measurable openings. The filter fabric shall provide an equivalent opening size (AOS) no finer than the US Standard Sieve No. 0.125 mm (No. 120) and no coarser than the US Standard Sieve No. 4.75 mm (No. 4). AOS is defined as the number of the US Standard sieve having openings closest in size to the filter fabric openings. The filaments shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, or vinylidene-chloride, and shall contain stabilizers and/or inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet and heat exposure. The fabric shall have a minimum physical strength of 444.8 N (100 pounds) in any direction when tested in accordance with ASTM D5034 or KS K 0743 using the grab test method with 645.2 square mm) (1 square inch) jaws and a constant rate of travel of 304.8 mm (12 inches) per minute. Elongation at failure shall be between 30 and 70 percent. The fabric shall be constructed so that the filaments will retain their relative position with respect to each other. The edges of the fabric shall be selvaged or otherwise finished to prevent the outer material from pulling away from the fabric. The fabric shall be woven into a width that may be installed as shown without longitudinal seams.

2.3 SUBDRAIN FILTER AND BEDDING MATERIAL

Subdrain filter and bedding material shall be washed sand, sand and gravel, crushed stone, crushed stone screenings, or slag composed of hard, tough, durable particles free from adherent coatings. Filter material shall not contain corrosive agents, organic matter, or soft, friable, thin, or elongated particles and shall be evenly graded between the limits specified in TABLE I. Gradation curves will exhibit no abrupt changes in slope denoting skip or gap grading. Filter materials shall be clean and free from soil and foreign materials. Filter blankets found to be dirty or otherwise contaminated shall be removed and replaced with material meeting the specific requirements, at no additional cost to the Government.

TABLE I

ASTM D422	Type I Gradation E 11 ASTM C33/C33M	Type II Gradation 57 ASTM C33/C33M
Sieve Size	Percent Passing	Percent Passing
37.5 mm	--	100
25.0 mm	--	90 - 100
9.5 mm	100	25 - 60
4.75 mm	95 - 100	5 - 40
2.36 mm	--	0 - 20
1.18 mm	45 - 80	--
300 micrometers	10 - 30	--
150 micrometers	0 - 10	--

TABLE I		
ASTM D422	Type I Gradation E 11 ASTM C33/C33M	Type II Gradation 57 ASTM C33/C33M
Sieve Size	Percent Passing	Percent Passing
1.5 inches	--	100
1 inch	--	90 - 100
3/8 inch	100	25 - 60
No. 4	95 - 100	5 - 40
No. 8	--	0 - 20
No. 16	45 - 80	--
No. 50	10 - 30	--
No. 100	0 - 10	--

2.4 DRAINAGE STRUCTURES

2.4.1 Concrete

Except for precast concrete, reinforcement shall conform to the requirements for 21 MPa (3,000 psi) concrete in Section 03 30 00 CAST-IN-PLACE CONCRETE. The concrete mixtures shall have air content, by volume of concrete, based on measurements made immediately after discharge from the mixer of 4 to 7 percent when coarse-aggregate maximum size is 38.1 mm (1-1/2 inches) or smaller. Air content shall be determined in accordance with ASTM C231/C231M or KS F 2421. The concrete covering over steel reinforcing shall be not less than 25.4 mm (1 inch) thick for covers and not less than 38.1 mm (1-1/2 inches) thick for walls and flooring. Concrete covering deposited directly against the ground shall be at least 76.2 mm (3 inches) thick between the steel and the ground. Expansion-joint filler material shall conform to ASTM D1751 or ASTM D1752 or KS F 2538. Exposed concrete surfaces, such as drainage structures that form a continuation of concrete curbs and gutters, shall be given a protective coating of linseed oil as specified in Section 32 16 13 CONCRETE SIDEWALKS AND CURBS AND GUTTERS.

2.4.2 Mortar

Mortar for pipe joints and connections to other drainage structures shall be composed of one part by volume of portland cement and two parts of sand. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of injurious acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes from the time the ingredients are mixed with water.

2.4.3 Manholes and Appurtenances

2.4.3.1 Precast Reinforced Concrete Manhole Risers and Tops

Conform to ASTM C478M (ASTM C478).

2.4.3.2 Precast Concrete Segmental Blocks

Precast concrete segmental blocks shall conform to ASTM C139 and shall be not more than 203.2 mm (8 inches) thick, not less than 203.2 mm (8 inches) long, and of such shape that the joints can be effectively sealed and bonded with cement mortar.

2.4.3.3 Precast Concrete Manhole Bases

If precast concrete manhole bases are used, the bases shall conform to ASTM C478M (ASTM C478) and shall be of such a design as to effect suitable connection with influent and effluent lines and to provide a suitable base structure for riser sections.

2.4.3.4 Brick

Brick shall conform to ASTM C62, Grade SW, or ASTM C55, Grade S-I or S-II. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in the amount of not more than 25 percent by volume of cement.

2.4.3.5 Prefabricated Corrugated Metal

Steel manholes and risers shall be fabricated of galvanized corrugated metal.

2.4.3.6 Glass Fiber-Reinforced Polyester (FRP)

FRP manholes shall conform to ASTM D3753.

2.4.3.7 Frames and Covers or Gratings

Frames and gratings, or frames and covers, except as otherwise permitted, shall be of either cast iron with tensile strength test not less than ASTM A48/A48M Class 175, KS D 4301, Type GC 200 or steel conforming to ASTM A27/A27M, Class 65-35 or KS D 4101. Weight, shape, and size shall be as indicated. Frames and covers not subjected to vehicular traffic or storage may be of malleable iron where indicated. The malleable-iron frames and covers shall conform to ASTM A47/A47M or KS D ISO 5922 and shall be of the weight, shape, and size indicated.

2.4.3.8 Steel Ladder

A steel ladder shall be provided where the depth of a manhole exceeds 3.66 m (12 feet). The ladder will be not less than 400 mm (16 inches) in width, with 19.1 mm (3/4 inch) diameter rungs spaced 304.8 mm (12 inches) apart. The two stringers shall be a minimum 9.5 mm (3/8 inch) thick and 50.8 mm (2 inches) wide. Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1.83 m (6 feet) apart vertically, and shall be so installed as to provide at least 152.4 mm (6 inches) of space between the wall and the rungs. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M or KS D 8308. The wall along the line of the ladder shall be vertical for its entire length.

2.5 COMPOSITE PREFABRICATED DRAINAGE SYSTEMS

Composite drains shall be installed behind all retaining walls to control and relieve potential hydrostatic pressures from groundwater and seepage.

2.5.1 Composite Drains

Composite drains shall consist of a nonwoven polyester or polypropylene filter fabric which is factory bonded to one side of a three-dimensional drainage core panel or strip. The drainage core shall be a high-impact resistant polymetric sheet of either polystyrene or high density polyethylene (HDPE) composition, and shall have high compression resistance and long-term durability. Composite drains shall be delivered to the site with the filter fabric already bonded to the drainage core by the product manufacturer. The bond between filter fabric and drainage core shall be of such strength that fabric distortion and intrusion into the core flow channels do not occur when the drain is backfilled against. Installation of the composite drains shall be continuous over the length of the retaining walls as delineated on the contract drawings and specified herein.

2.5.2 Filter Fabric

The filter fabric shall serve as a filtering media to allow the passage of groundwater into the drainage core while retaining backfill soil particles without clogging the open pores of the fabric. All seepage entering the drainage core shall be discharged by means of a perforated or slotted drain pipe running along the back of the retaining wall as shown on the contract drawings. Weep holes extending through the wall shall serve as the backup discharge system.

2.5.3 Composite Drains Products

2.5.3.1 Drainage Core

a. Thickness: minimum 11.5 mm (0.45 inch) (0.45 inch) per ASTM D1777.

b. Minimum Compressive Strength: 2.69 kg per square centimeter (5,500 psf) (5,500 psf) at max 10 percent deflection per ASTM D1621 or KS M ISO 844.

c. Composition: high density polyethylene or high-impact resistant polystyrene.

2.5.3.2 Filter Fabric (Minimum Average Roll Values)

a. Composition: nonwoven polyester or polypropylene.

b. Grab Tensile Strength: minimum 59 kg (130 pounds) (130 pounds) per ASTM D4632 or KS K 0520.

c. Grab Tensile Elongation (all directions): minimum 50 percent per ASTM D4632 or KS K 0743.

d. Trapezoidal Tear Strength: minimum 18 kg (40 pounds) (40 pounds) per ASTM D4533 or KS K 0537.

e. Mullen Burst Strength: minimum 95 kg (210 pounds) (210 pounds) per ASTM D3786/D3786M or KS K 0351.

f. Puncture Strength: minimum 18 kg (40 pounds) (40 pounds) per ASTM D4833 or KS K 0350.

g. Apparent Opening Size (AOS): 70 to 80 U.S. sieve size per ASTM D4751 or KS K 0754.

h. Water Flow Rate: minimum 150 gal per min per square foot per ASTM D4491 or KS F 2322.

i. Coefficient of Permeability: minimum 0.2 cm per sec per ASTM D4491.

j. Moisture Absorption: not less than 0.05 percent per ASTM D570 or KS M ISO 62. But square test specimen for homogeneous plastics, test specimen for rods, or test specimen for tubes shall be applied in case of KS M ISO 62.

k. UV Resistance: at least 70 percent of minimum grab tensile strength retained after 150 hours exposure per ASTM D4355.

2.5.3.3 Composite System

a. In-Plane Flow Capacity: minimum 11 gpm per foot width at 2,000 psf confining pressure and hydraulic gradient of 1.0 per ASTM D4716.

b. Fungus Resistance: no growth per ASTM G21.

c. Resistant to naturally occurring soil alkalis and acids in normal soil environments.

d. Product will not be eaten by insects or rodents.

e. Requires no maintenance after installation.

f. Width (Vertical Direction): complete wall coverage to the limits shown on the contract drawings, with filter fabric wrap extending a minimum of 75 mm (3 inches) (3 inches) beyond all terminal edges of the drainage core per roll, sheet or panel.

g. Length (Horizontal Direction): product roll or panel lengths as necessary to install continuous composite drains per contract drawings and specifications.

2.5.4 Storage and Handling

2.5.4.1 Composite Drains

Composite drains shall be labeled, stored, and handled according to ASTM D4873, the manufacturer's recommendations, and as provided in these specifications.

2.5.4.2 Protection

Drains shall be kept wrapped, dry, and protected from the elements at all times during shipping and storage. If stored outdoors, the drains shall be elevated above ground level and protected with a waterproof, opaque cover. The temperature of the stored products shall not be allowed to exceed 60 degrees C (140 degrees F) (140 degrees F).

2.5.4.3 Exposure

The Contractor shall limit the time composite drains are exposed to sunlight to a maximum 7 days. The period of exposure shall be measured from the time individual product rolls or panels are removed from their protective shipping wrappers until final coverage with backfill. If composite drains must be exposed for more than 7 days, the Contractor shall be required to protect the drains with an acceptable temporary cover for the duration of the delay, at no cost to the Government.

2.5.4.4 Maintenance

The Contractor shall protect the composite drains from damage or contamination from soil, mud, dust, or debris to mitigate any reduction in required strength and permeability of the product. The Contractor shall not operate equipment directly on the drains. The drains shall have no tears, punctures, or other defects which would adversely alter its physical properties. Damaged or otherwise defective drains shall be replaced with the same undamaged product, prior to installation, at no cost to the Government.

2.5.5 Installation Plan and Product Certification

2.5.5.1 Installation Plan

Before installing the composite drains, the Contractor shall submit the following to the Contracting Officer:

a. Two samples of each drain product (at 0.3 meter (1 foot) (1 foot), 2 each);

b. An installation plan detailing installation procedures for the composite drains;

c. A certification signed by an authorized quality control employee of the Manufacturer stating that the products meet or exceed technical specifications as listed in paragraphs 2.5.3.1, 2.5.3.2, and 2.5.3.3 above; and

d. Certified Manufacturer's laboratory test data for the following properties, at a minimum frequency of one test per 10,000 square meters (100,000 square feet) (100,000 square feet) of product produced:

   - Compressive strength for drainage core;

   - Grab tensile strength, puncture strength, mullen burst strength, trapezoidal tear strength, permeability, water flow rate, and AOS for the filter fabric; and

   - In-plane flow capacity for the composite system.

2.5.5.2 Product Certification

The Contractor shall not purchase composite drains for the project until product samples have been examined and all certifications and supporting laboratory test data have been reviewed and approved by the Contracting Officer. The Contractor shall not proceed with installation of composite drains until approval of the Installation Plan by the Contracting Officer has been granted.

2.6 WEEP HOLES

Weep Holes unless otherwise indicated or approved shall be schedule 40 PVC pipe conforming to ASTM D1785 or KS M 3404 VG1. Drain pipes shall be plastic pipe containing ultraviolet inhibitor to provide protection from exposure to direct sunlight.

PART 3 EXECUTION

3.1 EXCAVATION AND BEDDING FOR SUBDRAIN SYSTEMS

Trenching and excavation, including the removal of rock and unstable material, shall be in accordance with Section 31 00 00 EARTHWORK. Bedding material shall be placed in the trench as indicated or as required as replacement materials used in those areas where unstable materials were removed. Compaction of the bedding material shall be as specified for cohesionless material in Section 31 00 00 EARTHWORK.

3.2 MANHOLES AND FLUSHING AND OBSERVATION RISERS

3.2.1 Manholes

Manholes shall be installed complete with frames and covers or gratings at the locations and within the limits and sizes indicated. Manholes shall be constructed of one of the materials specified for manholes in paragraph DRAINAGE STRUCTURES. Joints shall be completely filled and shall be smooth and free of surplus mortar or mastic on the inside of the structure. Brick manholes shall be plastered with 12.7 mm (1/2 inch) of mortar over the entire outside surface of the walls. Brick for square or rectangular structures shall be laid in stretcher courses with a header course every sixth course. Brick for round structures shall be laid radially with every sixth course laid as a stretcher course. Ladders shall be installed in manholes as indicated. Base for manholes shall be either precast or cast-in-place concrete.

3.2.2 Flushing and Observation Risers

Flushing and observation riser pipes with frames and covers shall be installed at the locations indicated. Risers shall be constructed of precast concrete, vitrified clay, or galvanized or bituminous coated corrugated metal pipe. Joining of riser pipes to the subdrain system shall be as indicated.

3.3 INSTALLATION OF FILTER FABRIC AND PIPE FOR SUBDRAINS

3.3.1 Installation of Filter Fabric

3.3.1.1 Overlaps on Perforated or Slotted Pipes

One layer of filter fabric shall be wrapped around perforated or slotted collector pipes in such a manner that longitudinal overlaps of fabric are in unperforated or unslotted quadrants of the pipes. The overlap shall be at least 50 mm (2 inches). The fabric shall be secured to the pipe in such a manner that backfill material will not infiltrate through any fabric overlaps.

3.3.1.2 Installation on Open-Joint Pipe

One layer of filter fabric shall be wrapped around open joints. The overlap should be at least 50 mm (2 inches). The fabric shall be secured to the pipe in such a manner that backfill material will not infiltrate through the overlap or the edges of the fabric to either side of the open joint.

3.3.1.3 Trench Lining and Overlaps

Trenches to be lined with filter fabric shall be graded to obtain smooth side and bottom surfaces so that the fabric will not bridge cavities in the soil or be damaged by projecting rock. The fabric shall be laid flat but not stretched on the soil, and it shall be secured with anchor pins. Overlaps shall be at least 300 mm (12 inches), and anchor pins shall be used along the overlaps.

3.3.2 Installation of Pipe for Subdrains

3.3.2.1 Pipe Laying

Each pipe shall be carefully inspected before it is laid. Any defective or damaged pipe shall be rejected. No pipe shall be laid when the trench conditions or weather is unsuitable for such work. Water shall be removed from trenches by sump pumping or other approved methods. The pipe shall be laid to the grades and alignment as indicated. The pipe shall be bedded to the established gradeline. Perforations shall be centered on the bottom of the pipe. Pipes of either the bell-and-spigot type or the tongue-and-groove type shall be laid with the bell or groove ends upstream. All pipes in place shall be approved before backfilling.

3.3.2.2 Jointings

a. Nonperforated Concrete and Clay Pipe: Pipe shall be laid with 3.2 to 6.4 mm (1/8 to 1/4 inch) opening between the ends of the pipe or as required by spacing lugs constructed in the pipe. Mortar shall be placed in the joint at three points and pressed firmly into place to hold the pipe securely in line. The mortar shall be the full depth of the bell or groove and approximately 25.4 (1 inch) in width, and shall be located at the third points around the joint with the top point at the center of the pipe. The inside of the pipe shall be free of excess mortar.

b. Perforated Concrete and Clay Pipe: The pipe shall be laid with closed joints with positive provision for centering each section of the pipe in the bell or groove of the previously placed section. Plain-end perforated clay pipe sections shall be securely fastened together with spring wire clips furnished by the pipe manufacturer.

c. Perforated Corrugated Metal Pipe or Bituminous Coated, Perforated Corrugated Metal Pipe: The sections of perforated corrugated metal pipe or bituminous coated, perforated corrugated metal pipe shall be securely fastened together with standard connecting bands furnished by the manufacturer of the pipe.

d. Drain Tile: Drain tile shall be bedded as provided for bell-and-spigot or tongue-and-groove types of pipe and laid with open joints of approximately 3.2 mm (1/8 inch) width but not over 6.4 mm (1/4 inch) width. Drain tile shall be protected against the entrance of filter material into the line by the use of filter fabric.

e. Porous Concrete Pipe: Porous concrete pipe shall be installed with mortar joints.

f. Perforated Asbestos-Cement Pipe: Couplings shall be of the sleeve type suitable for holding the pipe firmly in alignment without the use of sealing compounds or gaskets. Tapered couplings will be acceptable.

g. Bituminous Coated or Uncoated Semicircular Steel Pipe: Coupling bands shall consist of an uncorrugated top and bottom section fabricated to fit around two adjacent pieces of pipe. Coupling bands shall be bolted together with four bolts.

h. Bituminous Coated or Uncoated Corrugated Aluminum Pipe: If aluminum pipe is to be connected to dissimilar metal, the connection shall be insulated by bituminous coating or other nonconductive material. Standard joints between corrugated aluminum pipes shall be securely fastened with standard connecting bands furnished by the manufacturer of the pipe.

i. Acrylonitrile-Butadiene-Styrene (ABS): Solvent cement or elastomeric joints for ABS pipe shall be in accordance with ASTM D2751. Dimensions and tolerances shall be in accordance with TABLE II of ASTM D2751.

j. Polyvinyl Chloride (PVC) Pipe: Joints shall be in accordance with the requirements of ASTM D3034, ASTM D3212, or ASTM F949.

k. Perforated Corrugated Polyethylene Pipe: Perforated corrugated polyethylene drainage pipe shall be installed in accordance with the manufacturer's specifications and as specified herein. A pipe with physical imperfections shall not be installed. No more than 5 percent stretch in a section will be permitted.

3.4 INSTALLATION OF AND BACKFILLING FOR BLIND OR FRENCH DRAINS

Filter material shall be placed as indicated and compacted as specified for cohesionless materials in Section 31 00 00 EARTHWORK. Filter material shall extend to a suitable outlet or to an outlet through a pipeline as indicated. Overlying backfill material shall be placed and compacted as specified in Section 31 00 00 EARTHWORK.

3.5 INSTALLATION OF FILTER MATERIAL AND BACKFILLING FOR SUBDRAINS

After pipe for subdrains has been laid, inspected, and approved, filter material shall be placed around and over the pipe to the depth indicated. The filter material shall be placed in layers not to exceed 200 mm (8 inches) thick, and each layer shall be thoroughly compacted by mechanical tampers or rammers to obtain the required density. Compaction of filter material and the placement and compaction of overlying backfill material shall be in accordance with the applicable provisions specified in Section 31 00 00 EARTHWORK.

3.6 TESTS

3.6.1 Pipe Test

Strength tests of pipe shall conform to field service test requirements of the Federal Specification, ASTM specification, or AASHTO specification covering the product (paragraph PIPE FOR SUBDRAINS).

3.7 INSTALLATION OF COMPOSITE DRAINS

3.7.1 General

Prior to installation, all surfaces to be in contact with the composite drains shall be prepared in a smooth condition, free of debris, depressions, or obstructions which could damage the product. The composite drains shall be placed loosely (not taut), and free of wrinkles or folds. Care shall be taken to eliminate voids between the drains and the adjacent substrate. Any necessary trimming of the drains shall be performed in a manner that will not damage the product or other underlying materials.

3.7.2 Repairs

All damaged or contaminated composite drains shall be immediately removed and replaced at the Contractor's own expense. Repairs shall be made with identical undamaged drain products. All repairs shall require prior approval of the Contracting Officer.

3.7.3 Installation Plan

General procedures for installing the composite drains behind project retaining walls are given below. The Contractor's Installation Plan shall provide detailed procedures for placing the drains, incorporating recommendations by the product manufacturer.

a. The composite drains shall be installed continuously along the entire length of the walls, at the elevations and depths shown on the contract drawings. The drains shall terminate 600 mm (2 feet) (2 feet) from the lateral ends of the walls.

b. The composite drains shall be installed with the drainage core facing the concrete wall. The composite drains shall be attached to the concrete substrate using nails driven through washers or wood lathing strips, mastic, double-sided tape, or other approved attachment methods such that drains will not detach from the wall during subsequent backfilling.

c. Drainage panels may be used to satisfy the requirement for composite drains provided said panels are properly overlapped to achieve continuous placement along the length of the wall. Panel overlapping shall always be performed in the direction of water flow. Drainage cores of adjacent panels shall be overlapped without sandwiching the filter fabric between the cores. Cores shall be overlapped at least 50 mm (2 inches) (2 inches). Overlap joints shall be covered with a terminal filter fabric flap at least 75 mm (3 inches) (3 inches) long.

d. The following procedures shall be followed for the drain pipe discharge system. The bottom fabric flap from the composite drains shall be peeled back, and the drain pipe shall be installed directly against the drain core. The fabric flap shall then be wrapped around the pipe and tucked behind the drain core. Care will be taken to achieve complete coverage and overlap of the filter fabric wrap.

e. As an extra precaution for insuring the complete and continual removal of all seepage collected by the composite drain system, the drainage core shall be punctured immediately behind all weep hole positions. Care shall be taken not to puncture the filter fabric opposite the weep holes.

f. All terminal ends of the installed composite drains shall be covered with the fabric flap by tucking it behind the core. For corners and other uneven surfaces, the fabric flap may be attached directly to the wall with mastic to prevent soil intrusion behind the drains.

g. Backfill shall be placed within 7 days of composite drain placement. Backfill directly against the drains shall be compacted in maximum 150 mm (6 inches) (6 inches) lifts using plate vibratory compactors. Exhaust from plate compactors shall always be directed away from the drains to prevent damage due to the hot exhaust gases.

3.8 INSTALLATION OF WEEP HOLES

Weep holes shall be installed at the spacing indicated. The drainage core shall be cut out to weep hole diameter immediately behind weep holes for water discharge. Care shall be taken not to puncture the filter fabric cover of the core. Non-biodegradable, non-metallic plates (polyvinyl chloride or other such materials) extending a minimum of three dimples in all directions shall be placed over the filter fabric at weep hole perforations.

-- End of Section --

SECTION 33 51 15

NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION
11/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.2	(2000) Diaphragm-Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 5L	(2007; Errata 2009; Addenda 1 2009; Addenda 2 2010; Addendum 2 2011; Addendum 3 2011; 44th Ed) Specification for Line Pipe
API Spec 6D	(2014; Errata 1-2 2014; Errata 3 2015) Specification for Pipeline Valves
API Std 1104	(2005; Errata/Adden 2007; Errata 2008; R 2010) Welding of Pipeline and Related Facilities

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-06	(2008) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C213	(2007) Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.40	(2008) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.8	(2010; Supplement 2010) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 25	(2008) Pressure Relief Devices

ASTM INTERNATIONAL (ASTM)

ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A139/A139M	(2004; R 2010) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM D1598	(2002; R 2009) Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D1599	(1999; R 2011) Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings
ASTM D2513	(2014; E 2014) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2517	(2006; R 2011) Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM D2683	(2010; E 2013; E 2014; E 2014) Standard Specification for Socket-Type Polyethylene

	Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D3261	(2012; E 2014) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D3350	(2010a) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3839	(2008) Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1541	(2009) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel socket-welding pipe Fittings
KS M 3514	(2001) Polyethylene (PE) Pipes for the Supply of Gaseous Fuels
KS M 3515	(2007) Polyethylene Fittings for Use with Polyethylene Pipes for the Supply of Gaseous fuels - Metric Series - Specifications - Electrofusion fittings having Two Different diameters
KS D 3562	(2009) Carbon Steel Pipes for Pressure Service
KS D 3589	(2009) Extruded polyethylene coated steel pipes
KS M ISO 8085-1	(2002) Polyethylene Fittings for Use with Polyethylene Pipes for the Supply of Gaseous fuels - Metric Series - Specifications - Part 1 : Fittings for Socket Fusion Using Heated Tools
KS M ISO 8085-2	(2002) Polyethylene Fittings for Use with Polyethylene Pipes for the Supply of Gaseous fuels - Metric Series - Specifications - Part 2 : Spigot Fittings for Butt Fusion, for Socket Fusion Using Heated Tools And for Use with Electrofusion Fittings
KS M ISO 8085-3	(2007) Polyethylene Fittings for Use with Polyethylene Pipes for the Supply of Gaseous fuels - Metric Series - Specifications - Part 3 : Electrofusion

Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends

MASTER PAINTERS INSTITUTE (MPI)

MPI 9	(Oct 2009) Exterior Alkyd, Gloss, MPI Gloss Level 6

NACE INTERNATIONAL (NACE)

NACE RP0274	(1974; R 2004) High Voltage Electrical Inspection of Pipeline Coatings
NACE SP0185	(2007) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 58	(2014; TIA 13-1; TIA 13-2; Errata 13-1; TIA 13-3; Errata 14-2) Liquefied Petroleum Gas Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II
SSPC SP 1	(1982; E 2004) Solvent Cleaning
SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning
SSPC SP 7/NACE No.4	(2007) Brush-Off Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

UNDERWRITERS LABORATORIES (UL)

UL Gas&Oil Dir	(2011) Flammable and Combustible Liquids and Gases Equipment Directory

1.2 SYSTEM DESCRIPTION

The gas distribution system includes natural gas piping and appurtenances from point of connection with existing system, as indicated, to a point approximately 1500 mm (5 feet) from the facility. Section 31 11 00 CLEARING AND GRUBBING, applies to this section unless otherwise specified. Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages. Submit Data packages, as specified.

1.2.1 Gas Distribution System and Equipment Operation

Include maps showing piping layout, locations of system valves, gas line markers and cathodic protection system test stations; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system maps); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data Package No. 4.

1.2.2 Gas Distribution System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No. 4.

1.2.3 Gas Distribution Equipment Maintenance

Include identification of valves and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pipe, Fittings, and Associated Materials

SD-03 Product Data

Materials and Equipment

Spare Parts
Pipe and Accessory Coatings

SD-05 Design Data

Connections to Existing Lines
Connection and Abandonment Plan; G
Jointing of Polyethylene and Fiberglass Piping

SD-06 Test Reports

Pressure and Leak Tests; G

SD-07 Certificates

Welder's training, qualifications and procedures
Utility Work

SD-10 Operation and Maintenance Data

Gas distribution system and equipment operation
Gas distribution system maintenance
Gas distribution equipment maintenance

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 Welding General

a. Submit a certificate of Welder's training, qualifications and procedures, in conformance with API Std 1104, for metal along with a list of names and identification symbols of performance qualified welders and welding operators.

b. Welding and nondestructive testing procedures for pressure piping are specified in Section 40 05 13.96 WELDING PROCESS PIPING.

c. Weld structural members in accordance with Section 05 05 23 WELDING, STRUCTURAL.

1.4.1.2 Jointing of Polyethylene and Fiberglass Piping

a. Join piping by performance qualified PE joiners, qualified by a person who has been trained and certified by the manufacturer of the pipe, using manufacturer's pre-qualified joining procedures in accordance with AGA XR0603. Inspect joints by an inspector qualified in the joining procedures being used and in accordance with AGA XR0603. Welders training, qualifications and procedures,(metal and PE) includes use of equipment, explanation of the procedure, and successfully making joints which pass tests specified in AGA XR0603.

b. Submit a certificate of qualified jointing procedures, training procedures, qualifications of trainer, and training test results for joiners and inspectors. Notify the Contracting Officer at least 24 hours in advance of the date to qualify joiners and inspectors.

1.4.2 Pre-Installation Conference

1.4.2.1 Shop Drawings

Submit shop drawings, within 30 days of contract award, containing complete schematic and piping diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout and anchorage of the system and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4.2.2 Connecting and Abandonment Plan

Submit written notification of the method and schedule for making connections to existing gas lines, to the Contracting Officer at least 10 days in advance. Include gas line tie in, hot taps, abandonment/removal or demolition, purging, and plugging as applicable in conformance with ASME B31.8 Include in submittal connections to existing lines or connection and abandonment plan.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to the site for damage, and store with a minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.2 Handling

Handle pipe and components carefully to ensure a sound, undamaged condition. Take particular care not to damage pipe coating. Repair damaged coatings to original finish. Do not place pipe or material of any kind inside another pipe or fitting after the coating has been applied, except as specified in paragraph INSTALLATION. Handle steel piping with coal-tar enamel coating in accordance with AWWA C203, and fusion-bonded epoxy coatings per AWWA C213. Handle plastic pipe in conformance with AGA XR0603.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of equipment and material specified, after approval of the detail shop drawings and not later than 1 month prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 PIPE, FITTINGS, AND ASSOCIATED MATERIALS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Provide written verification and point of contact for a supporting service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Mark all valves, flanges, and fittings in accordance with MSS SP-25. Submit a complete list of materials and equipment, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions, including, but not limited to the following:

a. Dielectric Waterways and Flange Kits.
b. Emergency Gas Supply Connection.
c. Fittings
d. Piping
e. Pipe and Accessory coatings
f. Pressure Reducing Valves.
g. Meters
h. Regulators.
i. Shut-off Valves
j. Earthquake Actuated Automatic Gas Shut-off System conforming to ASCE 25-06.

2.1.1 Steel Pipe

API Spec 5L, Grade A, B, or X42, ASTM A53/A53M, Grade A or B, ASTM A135/A135M, or ASTM A139/A139M, Grade A or B, Schedule 40 or KS D 3562 Schedule 40. Do not coat pipe and fittings for aboveground lines. Provide butt weld wrought steel fittings, conforming to ASME B16.9, Schedule 40 or KS B 1541. Provide forged steel socket weld and threaded fittings, conforming to ASME B16.11 or KS B 1542. Verify that pipe wall thickness conforms to ASME B31.8 for larger sizes and high pressures. Polyethylene coated steel pipe shall conform to KS D 3589, (KS D 3562, schedule 40) and shall be used underground.

2.1.2 Small Fittings

For sizes 40 mm (1-1/2 inches) and smaller, provide fittings conforming to ASME B16.11 or KS B 1542.

2.1.3 Fittings, 50 mm (2 inches) and Larger

Provide pipe flanges and flanged fittings, including bolts, nuts, and bolt patterns in accordance with ASME B16.5. Provide buttweld fittings in accordance with ASME B16.9 or KS B 1541. Use weld neck flanges.

2.1.4 Steel Forged Branch Connections

Provide steel forged branch connections conforming to ASTM A181/A181M, Class 60, carbon steel.

2.1.5 Flange Gaskets

Provide non-asbestos compressed material gaskets in accordance with ASME B16.21, 1.6 mm (1/16 inch) minimum thickness, full face or self-centering flat ring type, containing aramid fibers bonded with nitrile butadiene rubber (NBR), or glass fibers bonded with polytetrafluoroethylene, suitable for maximum 315 degrees C (600 degrees F) service and meeting applicable requirements of ASME B31.8.

2.1.6 Pipe Threads

Provide threaded pipe conforming to ASME B1.20.2M (ASME B1.20.1).

2.1.7 Polyethylene Pipe, Tubing, Fittings and Joints

Provide polyethylene pipe, tubing, fittings and joints conforming to ASTM D3350 and ASTM D2513, pipe designations PE 2406 and PE 3408, rated SDR 11 or less, as specified in ASME B31.8or KS M 3514. Mark pipe sections as required by ASTM D2513. Provide butt fittings conforming to ASTM D3261 and socket fittings conforming to ASTM D2683. Match fittings to the service rating of the pipe, with a minimum wall thickness as indicated on contract drawings. Perform underground installations in conformance with ASTM D2774. Local polyethylene pipe and tubing shall comply with KS M 3514 and fittings and joints shall comply with KS M 3515 or KS M ISO 8085-1 or KS M ISO 8085-2 or KS M ISO 8085-3 in accordance with the fitting and joint types.

2.1.8 Fiberglass Pipe, Fittings and Adhesive

Provide fiberglass pipe, fittings and adhesive conforming to ASTM D2517. Mark pipe sections as required by ASTM D2517, with indicated minimum wall thickness. Perform underground installations in conformance with ASTM D3839.

2.1.9 Sealants for Steel Pipe Threaded Joints

2.1.9.1 Sealing Compound

Provide joint sealing compound as listed in UL Gas&Oil Dir, Class 20 or less.

2.1.9.2 Tape

Provide polyetrafluoroethylene tape conforming to ASTM D3308.

2.1.10 Identification

Provide pipe flow markings and metal tags for each valve, meter, and regulator as required by the Contracting Officer.

2.1.11 Insulating Joint Materials

Provide insulating joint materials between flanged or threaded metallic pipe systems where shown to isolate galvanic or electrolytic action.

2.1.11.1 Threaded Joints

For threaded pipe joints, provide steel body nut type, dielectric waterways with insulating gaskets.

2.1.11.2 Flanged Joints

For flanged pipe joints, provide full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts and insulating washers for flange nuts.

2.1.11.3 Dielectric Waterways and Flanges

Provide dielectric waterways with temperature and pressure rating equal to or greater than that specified for the connecting piping, with metal connections on both ends suited to match connecting piping. Provide internally lined dielectric waterways, lined with an insulator specifically designed to prevent current flow between dissimilar metals, meeting the performance requirements described herein for dielectric waterways.

2.1.12 Gas Transition Fittings

Provide manufactured steel gas transition fittings approved for jointing steel and polyethylene or fiberglass pipe, conforming to AGA XR0603 requirements for transition fittings.

2.2 VALVES

Provide valves suitable for shutoff or isolation service and conforming to MSS SP-110, MSS SP-72 , MSS SP-78 and the following:

2.2.1 Steel Valves

Provide steel valves 40 mm (1-1/2 inches) and smaller installed underground conforming to ASME B16.34, carbon steel, socket weld ends, with square wrench operator adaptor. Provide steel valves 40 mm (1-1/2 inches) and smaller installed aboveground conforming to ASME B16.34, carbon steel, socket weld or threaded ends with handwheel or wrench operator. Provide steel valves 50 mm (2 inches) and larger installed underground conforming to API Spec 6D, carbon steel, buttweld ends, Class indicated on contract drawings, with square wrench operator adaptor. Provide steel valves 50 mm (2 inches) and larger installed aboveground conforming to API Spec 6D, carbon steel, buttweld or flanged ends, Class indicated on contract drawings, with handwheel or wrench operator.

2.2.2 Steel Valve Operators

Provide valves 200 mm (8 inches) and larger with worm or spur gear operators, totally enclosed, grease packed, and sealed, with operators having Open and Closed stops and position indicators. Provide locking feature where indicated. Wherever the lubricant connections are not conveniently accessible, provide extensions for the application of lubricant. Provide valves with lubricant compatible with gas service.

2.2.3 Polyethylene Valves

Provide polyethylene valves conforming to ASME B16.40. Polyethylene valves, in sizes 15 mm to 150 mm (1/2 inch to 6 inches), may be used with polyethylene distribution and service lines, in lieu of steel valves, for underground installation only.

2.3 PRESSURE REGULATORS

Provide ferrous bodied regulators with backflow protection, designed to meet the pressure, load and other service conditions.

2.3.1 Gas Main Regulators

Equip pressure regulators for main distribution lines, supplied from a source of gas which is at a higher pressure than the maximum allowable operating pressure for the system, with pressure regulating devices of adequate capacity. In addition to the pressure regulating devices, provide a protective method to prevent overpressuring of the system in accordance with ASME B31.8. Suitable protective devices are as follows:

a. Spring-loaded relief valve meeting the provisions of ASME BPVC SEC VIII D1.

b. Pilot-loaded back pressure regulator used as relief valve, so designed that failure of the pilot system will cause the regulator to open.

c. Weight-loaded relief valves conforming to ASME PTC 25.

d. Monitoring regulator installed in series with the primary pressure regulator.

e. Series regulator installed upstream from the primary regulator, set to limit the pressure on the inlet of the primary regulator continuously to the maximum allowable operating pressure of the system, or less.

f. Automatic shutoff device installed in series with the primary regulator, set to shut off when the pressure on the distribution system reaches the maximum allowable operating pressure of the system, or less, which remains closed until manually reset.

g. Spring-loaded, diaphragm type relief valves.

2.3.2 Service Line Regulators

a. Provide ferrous bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide regulators where gas will be distributed at pressures in excess of 2.5 kPa (10 inches of water column), with pressure relief set at a lower pressure than would cause unsafe operation of any connected user.

b. Adjust regulators for liquified petroleum gas to 2.5 to 3 kPa (10 to 12 inches of water column), with pressure relief set at 4 kPa (16 inches of water column).

c. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas pressure at the regulator inlet. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self contained service regulator, and pipe not exceeding exceed 50 mm (2 inch) size.

2.4 METERS

Provide meters conforming to AGA ANSI B109.2, pipeor pedestal mounted and be provided with a strainer immediately upstream. Provide meters with over-pressure protection as specified in ASME B31.8, tamper-proof protection, frost protection, fungus-proof protectionandseismic protection, suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 2.83 cubic meter (100 cubic feet) of gas.

2.5 EARTHQUAKE ACTUATED AUTOMATIC GAS SHUTOFF SYSTEM

Provide Earthquake Actuated Automatic Gas Shutoff devices conforming to ASCE 25-06, UL or AGA listed . The valve may be either pendulum or ball construction with remote pneumatic, electronic, or electric actuator. The system shall safely interrupt the flow of gas to the building due to strong ground shaking during an earthquake, but will not activate for minor ground shaking or accidental bumping by a pedestrian or vehicle.

2.6 EMERGENCY GAS SUPPLY CONNECTION

Provide an emergency gas supply connection consisting of piping (same size as service line) and accessories that will enable a portable, commercial-sized gas cylinder system to be connected to the gas piping system. Cap this connection to prevent gas leakage with a lockable manual valve located to allow shutting off flow. Provide the entire assembly in a weatherproof, lockable box, with permanently installed written instructions stating the type and pressure of the gas allowed to be connected to the line, and providing specific instruction for testing of the integrity of the building's gas system with an inert gas before the fuel gas connection is made. Provide a subplate in the box that is required to be unbolted to gain access to the connection, and containing a warning regarding the potential consequences of using gas other than that specified or of failing to test system integrity before hooking up emergency fuel supply.

2.7 PROTECTIVE COVERING MATERIALS

Provide a continuously extruded polyethylene and adhesive coating system material conforming to NACE SP0185, Type A.

2.8 TELEMETERING OR RECORDING GAUGES

Equip each distribution system supplied by more than one district pressure regulating station with telemetering or recording pressure gauges to indicate the gas pressure in the district line.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EXCAVATION AND BACKFILLING

Earthwork is as specified in Section 31 00 00 EARTHWORK.

3.3 GAS MAINS

Provide steel,polyethylene, or fiberglass pipe for gas mains. Coat steel pipe and fittings with protective covering as specified. Do not install polyethylene or fiberglass mains aboveground.

3.4 SERVICE LINES AND EMERGENCY GAS SUPPLY CONNECTION

3.4.1 General

Construct service lines of materials specified for gas mains and extend from a gas main to and including the point of delivery within 1.5 meters (5 feet) of the building. The point of delivery is the meter set assembly, service regulator, or shutoff valve, as indicated on contract drawings. Connect the service lines to the gas mains as indicated or through service tees, with end of run plugged. Where indicated, provide service line with an isolation valve of the same size as the service line. Make the service lines as short and as straight as practicable between the point of delivery and the gas main, without bends or lateral curves unless necessary to avoid obstructions or otherwise permitted. Lay service lines with as few joints as practicable using standard lengths of pipe, use shorter lengths only for closures. Do not install polyethylene or fiberglass service lines aboveground except as permitted in ASME B31.8.

3.4.2 Emergency Gas Supply Connection

Provide an aboveground locked, valved and capped emergency gas supply connection upstream of the pressure regulator, unless otherwise indicated on contract drawings, located outside of the building within 300 mm (12 inches) of the exterior wall and installed in a weatherproof box which is mounted on the exterior wall and clearly marked with an appropriate metal sign mounted on wall above.

3.5 WORKMANSHIP AND DEFECTS

Make pipe, tubing, and fittings clear and free of cutting burrs and defects in structure or threading, and thoroughly brushed and blown free of chips and scale. Do not repair, but replace defective pipe, tubing, or fittings.

3.6 PROTECTIVE COVERING

3.6.1 Protective Covering for Underground Steel Pipe

Except as otherwise specified, apply protective coverings mechanically in a factory or field plant especially equipped for the purpose. Hand apply protective covering to valves and fittings that cannot be coated and wrapped mechanically, preferably at the plant that applies the covering to the pipe. Coat and wrap joints by hand, in a manner and with materials that will produce a covering equal in thickness to that of the covering applied mechanically.

3.6.1.1 Thermoplastic Resin Coating System

Provide a thermoplastic coating system conforming to NACE SP0185, Type A. Clean the exterior of the pipe to a commercial grade blast cleaning finish in accordance with SSPC SP 6/NACE No.3, and apply adhesive compound to the pipe. Immediately after the adhesive is applied, extrude a seamless tube of polyethylene over the adhesive to produce a bonded seamless coating, with a nominal thickness of 0.25 mm (10 mils) (plus or minus 10 percent) of adhesive and 1.0 mm (40 mils) (plus or minus 10 percent) of polyethylene for pipes up to 400 mm (16 inches) in diameter. For pipes 450 mm (18 inches) and larger in diameter, apply a minimum thickness to the pipe of 0.25 mm (10 mils) (plus or minus 10 percent) adhesive and 1.5 mm (60 mils) (plus or minus 10 percent) polyethylene. Apply joint coating and field repair material as recommended by the coating manufacturer, consisting of one the following:

a. Heat shrinkable polyethylene sleeves.

b. Polyvinyl chloride pressure-sensitive adhesive tape.

c. High density polyethylene/bituminous rubber compound tape.

Inspect the coating system for holes, voids, cracks, and other damage during installation.

3.6.1.2 Inspection of Pipe Coatings

Repair any damage to the protective covering during transit and handling before installation. After field coating and wrapping has been applied, inspect the entire pipe using an electric holiday detector with impressed current set at a value in accordance with NACE RP0274 using a full-ring, spring-type coil electrode. Equip the holiday detector with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Immediately repair all holidays in the protective covering upon detection. The Contracting Officer reserves the right to inspect and determine the suitability of the detector. Furnish labor, materials, and equipment necessary for conducting the inspection.

3.6.2 Protective Covering for Aboveground Piping Systems

Apply finish painting conforming to the applicable paragraphs of Section 09 90 00 PAINTS AND COATINGS and as follows:

3.6.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer of the same type paint as the shop primer. Solvent-clean surfaces that have not been shop primed in accordance with SSPC SP 1. Mechanically clean surfaces that contain loose rust, loose mill scale, and other foreign substances by power wire brushing in accordance with SSPC SP 3 or brush-off blast clean in accordance with SSPC SP 7/NACE No.4 and primed with ferrous metal primer in accordance with SSPC Paint 25. Finish primed surfaces with two coats of exterior alkyd paint conforming to MPI 9.

3.6.2.2 Nonferrous Surfaces

Do not paint nonferrous surfaces, unless otherwise indicated on contract drawings.

3.6.3 Protective Covering for Piping in Valve Boxes and Manholes

Apply protective coating to piping in valve boxes or manholes as specified for underground steel pipe.

3.7 INSTALLATION

Install gas distribution system and equipment in conformance with the manufacturer's recommendations and applicable sections of ASME B31.8, AGA XR0603 and 49 CFR 192. Perform abandonment of existing gas piping in accordance with ASME B31.8. Cut the pipe without damaging the pipe; unless otherwise authorized, use an approved type of mechanical cutter. Use wheel cutters where practicable. On steel pipe 150 mm (6 inches) and larger, an approved gas-cutting-and-beveling machine may be used. Cut plastic pipe in accordance with AGA XR0603. Design valve installation in plastic pipe to protect the plastic pipe against excessive torsional or shearing loads when the valve is operated and from other stresses which may be exerted through the valve or valve box. Install polyethylene mains and service lines for LPG only below ground in accordance with NFPA 58.

3.7.1 Installing Pipe Underground

Grade gas mains and service lines as indicated. Weld joints in steel pipe except as otherwise permitted for installation of valves. Provide mains with 600 mm (24 inch) minimum cover; service lines with 485 mm (18 inch) minimum cover; and place both mains and service lines on firmly compacted select material for the full length. Where indicated, encase, bridge, or design the main to withstand any anticipated external loads as specified in ASME B31.8. Provide standard weight black steel pipe encasement material with a protective coating as specified. Separate the pipe from the casing by insulating spacers and seal the ends with casing bushings. Excavate the trench below pipe grade, bed with bank sand, and compact to provide full-length bearing. Laying pipe on blocks to produce uniform grade is not permitted. Ensure that the pipe is clean inside before it is lowered into the trench and keep free of water, soil, and all other foreign matter that might damage or obstruct the operation of the valves, regulators, meters, or other equipment. When work is not in progress, securely close open ends of pipe or fittings with expandable plugs or other suitable means. Minor changes in line or gradient of pipe that can be accomplished through the natural flexibility of the pipe material without producing permanent deformation and without overstressing joints may be made when approved. Make changes in line or gradient that exceed the limitations specified with fittings. When cathodic protection is furnished, provide electrically insulated joints or flanges. When polyethylene or fiberglass piping is installed underground, place foil backed magnetic tape above the pipe to permit locating with a magnetic detector. After laying of pipe and testing, backfill the trench in accordance with Section 31 00 00 EARTHWORK.

3.7.2 Installing Pipe Aboveground

Protect aboveground piping against dirt and other foreign matter, as specified for underground piping. Weld joints in steel pipe ; however, joints in pipe 40 mm (1-1/2 inches) in diameter and smaller may be threaded; joints may also be threaded to accommodate the installation of valves. Provide flanges of the weld neck type to match wall thickness of pipe.

3.8 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pullout forces caused by the contraction of piping or superimposed loads.

3.8.1 Threaded Steel Joints

Provide threaded joints in steel pipe with tapered threads evenly cut, made with UL approved graphite joint sealing compound for gas service or polytetrafluoroethylene tape applied to the male threads only. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.8.2 Welded Steel Joints

Perform gas pipe weldments as indicated. Make changes in direction of piping by welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Use forged or flared branch outlet fittings for improvement of flow where attached to the run, and reinforced against external strains. Perform all beveling, alignment, heat treatment, and inspection of welds conforming to ASME B31.8. Remove weld defects and repair the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect it or store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating.

3.8.3 Polyethylene and Fiberglass Pipe Jointing Procedures

Use jointing procedures conforming to AGA XR0603. Avoid making indiscriminate heat fusion joining of plastic pipe or fittings made from different polyethylene resins by classification or by manufacturer if other alternative joining procedures are available. If heat fusion joining of dissimilar polyethylene is required, special procedures are required. Test the method of heat fusion joining dissimilar polyethylene resins in accordance with paragraph TESTS, subparagraph Destructive Tests of Plastic Pipe Joints.

3.8.4 Connections Between Metallic and Plastic Piping

Only make metallic to plastic connections outside, underground, and with approved transition fittings.

3.9 VALVE BOXES

Provide valve boxes of cast iron not less than 4.7 mm (3/16 inch) thick at each underground valve except where concrete or other type of housing is indicated. Provide valve boxes with locking covers that require a special wrench for removal, and furnish the correctly marked wrench for each box. Cast the word "gas" in the box cover. When the valve is located in a roadway, protect the valve box by a suitable concrete slab at least 1 square meter (3 square feet). When in a sidewalk, provide the top of the box as a removable concrete slab 600 mm (2 feet) square and set flush with the sidewalk. Make the boxes adjustable extension type with screw or slide-type adjustments. Separately support valve boxes to not rest on the pipe, so that no traffic loads can be transmitted to the pipe. Only locate valves valve boxes or inside of buildings.

3.10 DRIPS

Install drips at locations where indicated, conforming to the details shown, or provide commercial units of approved type and capacity. Connect a blow off pipe 32 mm (1-1/4 inches) or larger to each drip at its lowest point and extend to or near the ground surface at a convenient location away from traffic. Provide a reducing fitting for each discharge at each drip terminal (outlet), a plug valve, and a 15 mm (1/2 inch) nipple turned down. Locate the discharge terminal (outlet) inside a length of 300 mm (12 inches) or larger vitrified clay pipe, concrete sewer pipe or concrete terminal box set vertically on a bed of coarse gravel 300 mm (1 foot) thick and 1 m (3 feet) square, with concrete bottom to contain liquids and a connection to remove liquids for disposal, and closed at the ground surface with a suitable replacement cover.

3.11 PRESSURE REGULATOR INSTALLATION

3.11.1 Main Distribution Line Regulators

Install pressure regulators where shown. Install a valve on each side of the regulator for isolating the regulator for maintenance. Provide a bypass line with bypass valves or 3 way valves and an over-pressurization pressure regulating device. Install regulators and valves in rectangular reinforced concrete boxes, large enough so that all required equipment can be properly installed, operated, and maintained, with box sidewalls extending above ground line. Provide the boxes with cast iron manhole covers, unless otherwise indicated on contract drawings, with locking provisions and 100 mm (4 inch) diameter vents. Furnish one key or other unlocking device with each cover. Locate discharge stacks, vents, or outlet ports of all pressure relief devices where gas can be discharged into the atmosphere without undue hazard. Provide stacks and vents with fittings to preclude entry of water.

3.11.2 Service Line Regulators

Install a shutoff valve, meter set assembly, and service regulator on the service line outside the building, 450 mm (18 inches) above the ground on the riser. Install an insulating joint on the inlet side of the meter set assembly and service regulator and construct to prevent flow of electrical current. Provide a 10 mm (3/8 inch) tapped fitting equipped with a plug on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.12 METER INSTALLATION

Install meters in accordance with ASME B31.8. Install permanent gas meters with provisions for isolation and removal for calibration and maintenance, and suitable for operation in conjunction with an energy monitoring and control system.

3.13 CONNECTIONS TO EXISTING LINES

Make connections between new work and existing gas lines, where required, in accordance with ASME B31.8, using proper fittings to suit the actual conditions. When connections are made by tapping into a gas main, provide the same size connecting fittings as the pipe being connected.

3.13.1 Connections to Publicly or Privately Operated Gas Utility Lines

Provide materials for the connections to the existing gas lines. The Utility is to make final connections and turn on the gas. The Utility is to also disconnect, purge and cap, plug or otherwise effectively seal existing lines that are to be abandoned or taken out of service. Notify the Contracting Officer, in writing, 10 days before final connections and turning on of gas lines. Make necessary arrangements with the Utility for tie in and activation of new gas lines. Only the Operating Agency/Utility Company may reactivate the system after tie in. Furnish a certification by the Operating Agency/Utility Company that all Utility work has been satisfactorily completed.

3.13.2 Connection to Government Owned/Operated Gas Lines

Provide connections to the existing gas lines in accordance with approved procedures. Only perform deactivation of any portion of the existing system at the valve location shown on the drawings. Reactivation of any existing gas lines will only be done by the Government. Submit the approved Contractor's Connection and Abandonment Plan prior to making any connections to existing gas lines, follow the Operating Agency's required procedures, which may be obtained from Directorate of Public Works (DPW). Notify the Contracting Officer, in writing, 10 days before connections to existing lines are to be made.

a. Physically disconnect from the pipeline system if facilities are abandoned in place. Purge, cap, plug or otherwise effectively seal the open ends of all abandoned facilities. Do not complete abandonment until it has been determined that the volume of gas or liquid hydrocarbons contained within the abandoned section poses no potential hazard. Use air or inert gas for purging, or fill the facility with water or other inert material. If air is used for purging, ensure that a combustible mixture is not present after purging.

b. When a main is abandoned, together with the service lines connected to it, only the customer's end of such service lines is required to be sealed as stipulated above.

c. Disconnect abandoned service lines from the active mains as close to the main as practicable.

d. Close all valves left in the abandoned segment.

e. Remove all above grade valves, risers, and vault and valve box covers. Fill vault and valve box voids with suitable compacted backfill material.

3.14 CATHODIC PROTECTION

Provide cathodic protection for all metallic gas piping installed underground and install as specified in Section 26 42 14.00 10 - CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE), Section 26 42 17.00 10 - CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT).

3.15 TESTS

3.15.1 Destructive Tests of Plastic Pipe Joints

Each day, prior to making polyethylene heat fusion joints or fiberglass adhesive joints, make a joint of each size and type to be installed that day by each person performing joining of plastic pipe that day and destructively test. Cut at least 3 longitudinal straps from each joint. Visually examine each strap for voids or discontinuities on the cut surfaces of the joint area, deformations by bending, torque, or impact. If failure occurs, it must not initiate in the joint area. If a joint fails the visual or deformation test, the qualified joiner who made that joint is not allowed to make further field joints in plastic pipe on this job until that joiner has been retrained and re-qualified. Record the results of the destructive tests including the date and time of the tests, size and type of the joints, ambient conditions, fusion iron temperature and names of inspectors and joiners.

3.15.2 Pressure and Leak Tests

Test the system of gas mains and service lines after construction and before being placed in service, using air as the test medium. Submit data in booklet form from all pressure tests of the distribution system. Conform testing to ASTM D1598 and ASTM D1599 for plastic piping. The normal operating pressure for the system and test pressure is as indicated on contract drawings.

a. Prior to testing the system, blow-out, clean, and clear the interior of all foreign materials. Remove all meters, regulators, and controls before blowing out and cleaning, and reinstall after clearing of all foreign materials.

b. Perform testing of gas mains and service lines with due regard for the safety of employees and the public during the test. Keep persons not working on the test operations out of the testing area while testing is proceeding. Perform the test on the system as a whole or on sections that can be isolated.

c. Test joints in sections prior to backfilling when trenches will be backfilled before the completion of other pipeline sections. Continue the test for at least 24 hours from the time of the initial readings to the final readings of pressure and temperature. Do not take the initial test readings of the instrument for at least 1 hour after the pipe has been subjected to the full test pressure. Do not take initial or final readings at times of rapid changes in atmospheric conditions, and temperatures are representative of the actual trench conditions. No indication of reduction of pressure is allowed during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2)=T(2)P(1), in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial and final readings.

d. During the test, completely isolate the entire system from all compressors and other sources of air pressure. Test each joint by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. Secure approval of testing instruments from the Contracting Officer. Furnish all labor, materials and equipment for conducting the tests subject to inspection at all times during the tests. Maintain safety precautions for air pressure testing at all times during the tests.

-- End of Section --

SECTION 33 56 10

FACTORY-FABRICATED FUEL STORAGE TANKS
01/08

PART 1 GENERAL

1.1 SUMMARY

This section defines the requirements for factory-fabricated fuel storage tanks.

1.1.1 Related Sections

1.1.1.1 Earthwork

Excavation and backfilling for tanks shall be as specified in Section 31 00 00 EARTHWORK.

1.1.1.2 Leak Detection

Leak detection shall be as specified in Section 33 58 00 LEAK DETECTION FOR FUELING SYSTEMS.

1.1.1.3 Cathodic Protection

Provide buried metallic components including pipe, anchors, conduit, etc., with a cathodic protection system as specified in Section 26 42 14.00 10 CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE) and Section 26 42 17.00 10 CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT) . Cathodic protection for metal components that attach to a tank shall be coordinated and compatible with the tank corrosion control system.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN PETROLEUM INSTITUTE (API)

API MPMS 2.2A	(1995; R 2007) Measurement and Calibration of Upright Cylindrical Tanks by the Manual Strapping Method
API MPMS 2.2E	(2004; Errata 2009; R 2009) Petroleum and Liquid Petroleum Products - Calibration of Horizontal Cylindrical Tanks - Part 1: Manual Methods

API RP 1615	(2011) Installation of Underground Petroleum Storage Systems
API RP 2003	(2008; 7th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 540	(1999; R 2004) Electrical Installations in Petroleum Processing Plants
API Std 1631	(2001) Interior Lining and Periodic Inspection of Underground Storage Tanks

ASME INTERNATIONAL (ASME)

ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2014) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A27/A27M	(2010) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A563	(2007a; R2014) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B26/B26M	(2012) Standard Specification for Aluminum-Alloy Sand Castings
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM F844	(2007a) Washers, Steel, Plain (Flat), Unhardened for General Use

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1100	(2005) Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment
IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2015) Flammable and Combustible Liquids Code
NFPA 30A	(2012; Errata 2011) Code for Motor Fuel Dispensing Facilities and Repair Garages
NFPA 407	(2012; TIA 11-1) Standard for Aircraft Fuel Servicing
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 77	(2007) Recommended Practice on Static Electricity
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

STEEL TANK INSTITUTE (STI)

STI F894	(2010) ACT-100 (R) Specification for External Corrosion Protection of FRP Composite Steel USTs
STI F911	(1998) Standard for Diked Aboveground Storage Tanks
STI P3	(2010) Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks
STI R912	(2009) Installation Instructions for Shop Fabricated Aboveground Tanks for Flammable, Combustible Liquids

UNDERWRITERS LABORATORIES (UL)

UL 1316	(1994; Reprint May 2006) Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products,

	Alcohols, and Alcohol-Gasoline Mixtures
UL 142	(2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 1746	(2007) External Corrosion Protection Systems for Steel Underground Storage Tanks
UL 2085	(1997; Reprint Sep 2010) Protected Aboveground Tanks for Flammable and Combustible Liquids
UL 58	(1996; Reprint Jul 1998) Steel Underground Tanks for Flammable and Combustible Liquids

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3755	(2008) Alloy Steel Bolting Materials for High Temperature Service

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Grounding and Bonding

SD-03 Product Data

Aboveground Storage Tank
Underground Storage Tank
Tank Protective Coatings
Automatic Level Alarm System
Tank Gauges
Manway Containment Sump
Tank Mounted Fuel Dispensing Unit
Fuel Heaters

SD-06 Test Reports

Aboveground Storage Tank Tightness Tests; G
Underground Storage Tank Tightness Tests; G
Tank Manufacturer's Tests
Tank Fill Tests

SD-07 Certificates

Contractor Qualifications
Permitting
Registration
Licensed Personnel
Demonstrations

SD-08 Manufacturer's Instructions

Aboveground Storage Tank
Underground Storage Tank
Automatic Level Alarm System
Tank Gauges
Fuel Heaters

SD-10 Operation and Maintenance Data

Aboveground Storage Tank
Underground Storage Tank
Automatic Level Alarm System
Tank Gauges
Fuel Heaters

1.4 QUALITY ASSURANCE

1.4.1 Contractor Qualifications

Each installation Contractor shall have successfully completed at least 3 projects of the same scope, and the same size or larger within the last 6 years, and demonstrated specific installation experience in regard to the specific system installation to be performed. Each installation Contractor shall have taken, if applicable, manufacturer's training courses on the installation of storage tanks and shall meet all applicable licensing requirements in the state. Submit a letter listing prior projects, the date of construction, a point of contact for each prior project, the scope of work of each prior project, and a detailed list of work performed. The letter shall also provide evidence of prior manufacturer's training, state licensing, and other related information.

1.4.2 Regulatory Requirements

1.4.2.1 Permitting

Obtain necessary permits in conjunction with the installation of underground storage tanks as required by federal, state, or local authority.

1.4.2.2 Registration

Obtain and complete all required tank registration forms required by federal, state, and local authorities. Submit all tank registration forms within 30 days after contract award. The Contracting Officer will submit the forms to the proper regulatory agencies.

1.4.2.3 Licensed Personnel

Tank installers shall be licensed/certified as required IAW with ROK national, provincial, and local laws and regulations.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 PROJECT/SITE CONDITIONS

Exposed moving parts, parts that produce high operating temperatures and pressures, parts that may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products that are of a similar material, design and workmanship. Provide materials and equipment that have been in satisfactory commercial or industrial use for a minimum 2 years prior to bid opening. The 2 year period shall include applications of the equipment and materials under similar circumstances and of similar size. Provide materials and equipment that have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.

2.1.2 Nameplates

Attach nameplates to all specified equipment defined herein. List on each nameplate the manufacturer's name, address, contract number, acceptance date, component type or style, model or serial number, catalog number, capacity or size, and the system that is controlled. Construct plates of anodized aluminum, stainless steel, melamine plastic, 3 mm (0.125 inch) thick, UV resistance, black with white center core, matte finish surface and square corners. Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be the normal block style with a minimum 6 mm (0.25 inch) height. Accurately align all lettering on nameplates. For plastic nameplates, engrave lettering into the white core. Key the nameplates to a chart and schedule for each system. Frame charts and schedule under glass, and locate where directed near each system. Furnish two copies of each chart and schedule. Each nameplate description shall identify its function.

2.2 MATERIALS

Internal parts and components of equipment, piping, piping components, and valves that could be exposed to fuel during system operation shall not be constructed of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.3 ELECTRICAL WORK

Provide controllers, integral disconnects, contactors, controls, and control wiring with their respective pieces of equipment. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide switches and devices necessary for controlling and protecting electrical equipment. Controllers and contactors shall have a maximum of 120-volt control circuits and shall have auxiliary contacts for use with the controls provided.

2.3.1 Underground Wiring

Enclose underground electrical wiring in PVC coated conduit. Dielectrically isolate conduit at any steel storage tank connection.

2.3.2 Grounding and Bonding

Grounding and bonding shall be in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.4 ABOVEGROUND STORAGE TANK

2.4.1 Steel Tank With Integral Steel Supports

Provide a factory-welded, single wall steel tank that conforms to NFPA 30, NFPA 30A, and UL 142. Tank shall be designed and manufactured for a horizontal cylindrical installation, unless otherwise indicated. Tank shall be mounted on the tank manufacturer's standard UL listed tank saddles or support skid that elevate the tank above the underlying concrete slab a minimum of 305 mm (12 inches). Support skid shall span the entire length of the tank. Provide a minimal 19 L (5 gallon) overfill containment box on the tank fill line. The containment box shall be lockable and shall contain any spillage encountered at the tank during tank filling operations.

2.4.2 Secondarily Contained Steel Tank

Provide a factory-assembled unit that includes a primary storage tank and an integral factory-fabricated secondary containment. Tank assembly shall be in accordance with NFPA 30 and NFPA 30A and be designed and manufactured for a horizontal cylindrical installation, unless otherwise indicated. Primary storage tank shall be factory-welded, steel that conforms to UL 142. Tank assembly shall be mounted on the tank manufacturer's standard UL listed support skid that elevates the tank assembly above the underlying concrete slab a minimum of 305 mm (12 inches). Tank assembly shall have lifting lugs that allow tank relocation. Provide tank assembly with the manufacturer's standard external ladder and platform assembly, except as modified herein. The ladder and platform assembly shall be constructed of structural steel and shall allow personal access to the top of the tank system. Provide a minimal 19 L (5 gallon) overfill containment box on the tank fill line. The containment box shall be lockable and shall contain any spillage encountered at the tank during tank filling operations.

2.4.2.1 Open-Top Containment

The secondary containment reservoir shall be the factory-fabricated, open-top, steel type that conforms to STI F911. The primary storage tank shall be supported within the containment reservoir with steel tank saddles or other similar supports, fabricated and attached by the tank manufacturer. The containment reservoir shall be designed to minimize entry of rainwater or blowing debris. The containment reservoir shall be equipped with a 75 mm (3 inches) drain that includes a full line size carbon steel drainage line and a full line size ball or gate valve.

2.4.2.2 Fully-Enclosed Steel Containment

The secondary containment reservoir shall be the factory-fabricated, steel type that fully-encloses the primary storage tank. The containment reservoir shall conform to UL 142. The interstitial space between the primary tank and the containment reservoir shall be both pressure testable and verifiable. The entire tank assembly shall conform to UL 2085. Tank assembly shall bear the UL 2085 label as a protected tank. The primary storage tank shall be supported within the containment reservoir with steel tank saddles or other similar supports, fabricated and installed by the tank manufacturer.

2.4.2.3 Fully-Enclosed Concrete Containment

The secondary containment reservoir shall be the factory-fabricated, concrete type that fully-encloses the primary storage tank. Concrete shall have a minimum 20.7 MPa) (3000 psi) strength, be monolithically poured, and be properly reinforced for the application. The primary storage tank shall be isolated from the exterior concrete containment with either insulation, an inert material, or minimum 50 mm (2 inches) standoffs. The interstitial space between the primary tank and the containment reservoir shall be both pressure testable and verifiable. The entire tank assembly shall conform to UL 2085. Tank assembly shall bear the UL 2085 label as a protected tank. No exterior enclosure shall be allowed to cover the reinforced concrete.

2.5 UNDERGROUND STORAGE TANK

Provide a factory-fabricated, double-walled type storage tank that conforms to NFPA 30 and NFPA 30A. Tank shall be designed and manufactured for an underground, horizontal installation. The exterior tank walls shall be separated from the interior tank walls by standoffs; thus creating an open or interstitial space (Type II). The entire interstitial space shall be monitorable for leaks. For tanks requiring concrete anchor pads or concrete deadmen, provide hold-down straps and accessories as recommended by the tank manufacturer. Use filler strips between the tank shell and any metal hold-down straps that conform to the tank manufacturer's requirements.

2.5.1 Double-Walled Steel Tank

Tank shall be constructed of steel and shall conform to UL 58, Type II. Tanks constructed with lap welded shell or head joints shall be continuous fillet welded; on both the interior and exterior surfaces. The UL 58 label shall be affixed to the exterior surface of the tank.

2.5.2 Double-Walled FRP Tank

Tank shall be constructed of fiberglass reinforced plastic (FRP) and shall conform to UL 1316. The UL 1316 label shall be affixed to the exterior surface of the tank.

2.6 TANK PROTECTIVE COATINGS

2.6.1 Interior Surfaces

Coat 100 percent of a metal tank's interior surfaces including all metal piping and metal appurtenances as specified in API Std 1631.

2.6.2 Exterior Surfaces, Aboveground Tanks

Protect the exterior surfaces of each aboveground tank with the manufacturer's standard coating system as modified herein.

2.6.3 Exterior Surfaces, Underground Tanks

Provide steel tanks with one of the following corrosion protection systems.

2.6.3.1 FRP Coating System

Coating system shall be in accordance with UL 1746 or STI F894. The integrity of the coating shall be certified by the manufacturer as meeting the thickness requirements and having no flaws prior to shipment. The UL and/or STI label(s) shall be affixed and visible on the exterior surface of each coated tank.

2.6.3.2 STI P3 System

Coating system shall be in accordance with STI P3. Tank manufacturer shall be licensed by the Steel Tank Institute as an applicator of the STI P3 system. The STI label shall be affixed and visible on the exterior surface of each coated tank.

2.7 TANK COMPONENTS

2.7.1 Tank Manway

Tank manway shall have an internal diameter of 915 mm (36 inches), unless otherwise indicated. Provide each manway with a matching flanged watertight manway cover. Manway covers shall be UL listed, be constructed of pressed or mild steel, and include a UL listed gasket. Frame and cover assembly shall be rated to withstand H-20 highway loading as defined by AASHTO HB-17.

2.7.2 Tank Piping Penetrations

Provide a welded-in-place double tapered National Pipe Thread (NPT) coupling for each tank piping connection.

2.7.3 Tank Striker/Impact Plates

Provide an interior striker/impact plate under each tank manway and pipe connection. Each plate shall be a minimum of 6 mm (1/4 inch) in thickness, be larger in diameter than the tank penetration, fit the curvature of the tank bottom, and be completely coated in the same fashion as the interior tank bottom coating. Each plate shall be welded to the tank bottom at the factory (full circumference connection).

2.7.4 Tank Cleanout and Gauge Assembly

Provide a combination cleanout and gauge assembly. The assembly shall include a bronze top-seal type adapter with a corresponding locking type cap (adapter and cap both externally-mounted to the top of the tank) and a steel or aluminum pipe mounted internal to the tank. The pipe shall be a minimum 50 mm (2 inches) in size and extend downward through the top of the tank to within 75 mm (3 inches) of the tank bottom. Provide the entire length of pipe inside the tank with 13 mm (1/2 inch) wide by 300 mm (12 inches) long slots at alternate locations. Coat the pipe in the same fashion as the interior tank bottom coating.

2.7.5 Tank Ladder

Provide interior tank ladders constructed of either fiberglass or steel. If steel, coat the ladder in the same fashion as the tank interior. The two stringers shall be a minimum 10 mm (3/8 inch) thick and a minimum 50 mm (2 inches) wide. The rungs shall be a minimum 20 mm (3/4 inch) rod on 300 mm (12 inches) centers. Members of the ladder shall be securely affixed. Ladder shall be of sufficient length to extend from the bottom of the tank to the top surface of the tank. Ladder shall be rigidly connected to the tank bottom in accordance with the tank manufacturer's standard. Ladder shall be connected to the top of the tank with pipe guides or slip bars to accommodate expansion of the two stringers.

2.7.6 Aboveground Tank Emergency Vent

Vent shall be the normally-closed, UL listed type that vents outward and upward. Vent shall conform with NFPA 30 and UL 142. Provide vent with the Liters per second (L/s) (cubic feet per minute (cfm)) rating permanently labeled on the vent's exterior.

2.8 AUTOMATIC LEVEL ALARM SYSTEM

Provide a system that will monitor 3 programmable liquid level set points. The system shall delineate between each individual setpoint as well as each individual tank. The system shall produce an audible and visible alarm in the event of monitoring an alarm condition. Mechanically-actuated float assemblies shall be field adjustable. The system shall be totally independent of the tank gauging system.

2.8.1 Set points

Configure the alarm system's 3 set points in accordance with the following.

a. High Level Setpoint. Produce an alarm condition when a tank's liquid level rises above 90 percent capacity.

b. High-High Level Setpoint. Produce an alarm condition when a tank's liquid level rises above 95 percent capacity.

c. Low Level Setpoint. Produce an alarm condition when a tank's liquid level drops below 15 percent capacity.

2.8.2 Control Panel

Install the control panel for the alarm system in a NEMA 4 rated enclosure in accordance with NEMA 250 standard industrial enclosure. Panel doors shall swing left or right.

2.8.2.1 Audible Alarm

Panel shall have internal, external speakers that produce a buzzer sound of 70 decibels or greater in the event of a detected alarm condition.

2.8.2.2 Visual Alarm

Panel shall have a visual alarm that illuminates in the event of a detected alarm condition. The visual alarm shall include either individual lights for each alarm condition or shall include a single light and a liquid crystal display (LCD) panel that displaces information regarding each alarm condition.

2.8.2.3 Acknowledge Switch

Panel shall have a manual acknowledge switch that will deactivate the audible alarm. The acknowledge switch shall not deactivate subsequent audible alarms unless depressed manually again for each occurrence. Under no circumstance shall this acknowledgement switch extinguish the visual alarms until the alarm condition has been corrected. The acknowledge switch shall be an integral component located on the front of the control panel. The switch shall be either a key switch or push button.

2.9 TANK GAUGES

2.9.1 Stick Gauge

For each tank, provide 2 wooden stick gauges. Gauge length shall allow the measurement of the entire level of fuel in the corresponding tank. Gauges shall be compatible with the fuel to be measured (no swelling or damage from fuel contact). Provide gauge with non-sparking caps on each end. Mark gauges in m and mm (feet and inches). The smallest unit of measure on the gauge shall be 1 mm (1/16 inch).

2.9.2 Tank Strapping Table

Furnish 1 API MPMS 2.2E, API MPMS 2.2A certified strapping table (calibration charts) for each tank. Table shall indicate the liquid contents in L (gallons) for each 1 mm (1/16 inch) of tank depth. For each tank, provide an electronic media file of each strapping table.

2.9.3 Analog Tank Gauge

Gauge shall be the level sensing, mechanically actuated type that provides the tank level readout in a sealed glass cap contained in a gauge box. Gauge shall be accurate to plus or minus 6 mm (1/4 inch) and shall measure the liquid level over the full range of a tank's height. Gauge shall have vapor tight seals to prevent condensation from fogging the viewing glass.

2.9.4 Hydrostatic Tank Gauge System

System shall be the dial type calibrated in Liters (gallons). Gauge shall be manually actuated using a built-in hand pump. The transmission line from the gauge to the tank shall be seamless copper tubing run in Schedule 80 PVC carrier pipe. The tank assembly (fittings, air bells, and tubing) shall be installed according to the gauge manufacturer's recommendations.

2.9.5 Digital Tank Gauge System

Gauge system shall be the mechanically or electronically actuated type that can continuously monitor a tank's usable liquid level storage capacity. The system shall provide a digital readout of a tank's liquid level in terms of mm and L (inches and gallons). The system shall be accurate to plus or minus 2 mm (1/16 inch). The system shall measure water accumulation in mm (inches) from 20 to 125 mm (3/4 to 5 inches) off the bottom of a storage tank. Construct system components to be chemically compatible with the fuel to be handled. For each tank monitored, provide a sending unit that transmits the digital readout from a tank to the electronic monitoring/alarm panel defined in Section 33 58 00 LEAK DETECTION FOR FUELING SYSTEMS an electronic display panel. Panel shall be a NEMA 4 enclosure as defined by NEMA 250 standard industrial enclosure. Panel doors shall swing left or right. The panel shall display the digital readout of each monitored tank on an LCD mounted exterior to the panel. The panel shall also have external controls to allow operators to toggle between information on the LCD without having to open the panel.

2.10 MANWAY CONTAINMENT SUMP

Sump shall be the factory-fabricated, direct-buried type that provides a watertight connection either directly to the exterior of the tank or to a flanged manway opening. Sump shall be constructed of either fiberglass reinforced plastic or molded polyethylene. Sump construction shall be chemically compatible with the type of products being handled within the connecting tank. Sump shall allow access to a tank manway cover without disturbing surrounding backfill. Sump shall be larger in diameter than the connecting tank manway. Sump shall be designed to withstand the underground burial loads. Sump assembly shall prevent the influx of rainfall drainage or ground water.

2.10.1 Piping Penetrations

Sump sides shall allow the penetration of carrier pipes, exterior containment pipes, conduits, and vapor pipes as required. Sump penetrations shall be booted or sealed to ensure that liquid will not escape from the sump in the event that the liquid level within the sump rises above the pipe penetration. Boots and seals used shall be compatible with the fuel to be handled. Boots and seals shall be water resistant to the influx of water from outside the sump. Boots and seals shall be designed and installed to accommodate the anticipated amount of thermal expansion and contraction in the piping system.

2.10.2 Access Cover

Where indicated, the entire top of a containment sump shall be capped with a friction fit bolted down, watertight access cover. Cover shall be constructed of the same material as the sump. Cover shall have a larger diameter than the tank manway cover below.

2.11 TANK MOUNTED FUEL DISPENSING UNIT

Provide fuel dispensing unit with integral UL labeled suction pump as supplied by the tank manufacturer. Unit shall include all necessary appurtenances for operation. Unit shall include a visible register to indicate individual deliveries up to 999.9 liters (99.9 gallons) with a reset meter. Pump shall have a delivery capacity of 0.95 liters/sec (15 gpm). Hose shall be a minimum 20 mm (3/4 inch) inside diameter, 4.6 meters (15 ft) long, and fuel resistant. The dispensing nozzle shall be of the automatic shutoff type with graduated notches for various delivery speeds. Dispensing unit shall provide a means for locking of the nozzle to the pump when the pump is shutoff. Diesel fuel dispensing unit cabinet shall be painted yellow from the manufacturer. Gasoline dispensing unit shall be painted red from the manufacturer. Units shall be clearly marked for the fuel they are dispensing.

2.12 FUEL HEATERS

2.12.1 In-Tank Heater

2.12.1.1 Fintube Type

Provide a vertical, manway-mounted, fintube immersion heater. Construct entire assembly to be compatible with the product to be heated. Entire assembly shall be removable as a unit. Construct heater's coil of carbon steel, stainless steel tubes and fins. Construct heater to work with a heating medium of steamor hot water supplied at temperature and pressure as indicated on contract drawings. Construct heater's tank mounting flange of steel with a bolt pattern to match the corresponding tank manway. Provide ASME B16.5, Class 150 flanges on the heating medium inlet and outlet. Extend assembly within 150 mm (6 inches) of the tank bottom.

2.12.1.2 Electric Type

Provide a flanged, horizontally-mounted, immersion type electric heater. Heater shall be UL listed and be compatible with the product to be heated. Construct heater's mounting flange of steel with a bolt pattern to match the corresponding tank nozzle. Heating element shall be non-coking for the intended application. Entire assembly shall be removable as a unit. If support brackets are required internally in a tank to mount the heating element above the tank bottom, provide heater manufacturer's standard support brackets. Install support brackets directly on a tank's internal striker plates. Mounting a heater's support brackets directly to a tank's bottom shall not be allowed.

2.12.2 Tank Suction Heater

2.12.2.1 Shell-and-Tube Type

Provide a vertical, manway-mounted, shell-and-tube type suction heater. Construct heater in accordance with ASME BPVC SEC VIII D1 with a rated working pressure of 1034 kPa (gage) (150 psig). Assembly shall be compatible with the product to be heated. Entire assembly shall be removable as a unit. Construct heater's shell and tube bundle of carbon steelor stainless steel. Construct heater to work with a heating medium of steamor hot water supplied at temperature and pressure as indicated on contract drawings. Construct heater's tank mounting flange of steel with a bolt pattern to match the corresponding tank manway. Provide ASME B16.5, Class 150 flanges on the heating medium inlet and outlet as well as the suction discharge piping. Extend assembly within 150 mm (6 inches) of the tank bottom. Provide heater with drain, vent, thermometer, and pressure gage.

2.12.2.2 Electric Type

Provide a flanged, horizontally-mounted, electric type suction heater.

Heater shall be UL listed and be compatible with the product to be heated. Construct heater's mounting flange of steel with a bolt pattern to match the corresponding tank nozzle. Heating element shall be non-coking for the intended application. Entire assembly shall be removable as a unit. Provide ASME B16.5, Class 150 flanges on the suction discharge piping. Provide heater with drain, vent, thermometer, and pressure gage. If support brackets are required internally in a tank to mount the heating element up off the tank bottom, provide heater manufacturer's standard support brackets. Install support brackets directly on a tank's internal striker plates. Mounting a heater's support brackets directly to a tank's bottom shall not be allowed.

2.12.3 Pipe In-Line Heater

Provide a horizontal, shell-and-tube type in-line heater. Construct heater in accordance with ASME BPVC SEC VIII D1 with a rated working pressure of 1034 kPa (gage) (150 psig). Construct entire assembly to be compatible with the product to be heated. Construct heater's shell and tube bundle of carbon steel, stainless steel. Construct heater to work with a heating medium of steamor hot water supplied at temperature and pressure as indicated on contract drawings. Provide ASME B16.5, Class 150 flanges on the heating medium inlet and outlet as well as the fuel inlet and outlet connections. Provide heater with manufacturer's standard support brackets. Provide heater with drain, vent, thermometer, and pressure gage.

2.12.4 Temperature Controls

Provide heater with automatic temperature controls that can regulate the discharge product temperature as indicated. Provide necessary sensors and wiring needed for a fully functional control system. Construct controls to allow for adjustable discharge product temperatures. Provide an automatic high limit safety heater shutoff that is field adjustable. Provide a manual "on-off" switch in series with the automatic temperature controls in order to allow manual shutdown/startup. Provide temperature control components in a mountable and prewired NEMA 4 enclosure that conforms to NEMA 250.

2.13 INSPECTION WELL

Inspection well shall be constructed of Schedule 40 PVC pipe that is 150 mm (6 inches) in diameter. Pipe shall be factory slotted from the bottom to within 300 mm (12 inches) of grade. With the pipe installed vertically, slots shall be horizontal and have a width of 0.5 mm (0.02 inch) with not less than 30 slots per 300 mm (ft). Slots shall encompass at least 80 percent of the pipe's 360 degree perimeter with the pipe maintaining its structural integrity. Slots shall allow fluid within the soil to infiltrate into the pipe without allowing sediment to fill the pipe. Each well shall extend down 600 mm (2 ft) below the deepest buried storage tank. Well shall have a permanently fixed bottom cap. Well shall have a removable top cap that is protected from traffic with a watertight street manway and cover as indicated. Well shall have a 10 mm (3/8 inch) vent hole located directly below the top cap to vent the well. The top cap of each well shall be accessible from the surface through a 300 mm (12 inches) diameter manhole. The manhole ring shall be constructed of steel, cast iron, or fiberglass, have a cast iron cover, be a minimum of 300 mm (12 inches) deep, and withstand H-20 highway loading as defined by AASHTO HB-17. Each manhole cover shall have the words "DO NOT FILL - INSPECTION WELL" cast permanently into the top. The letters shall be a minimum of 13 mm

(1/2 inch) in size. Each manhole cover shall have a white circle with a black triangle painted on the surface.

2.14 ACCESSORIES

2.14.1 Concrete Anchor Bolts

Concrete anchors shall conform to ASTM A307, Grade C, hot-dipped galvanized.

2.14.2 Bolts and Studs

Carbon steel bolts and studs shall conform to ASTM A307, Grade B, hot-dipped galvanized. Stainless steel bolts and studs that conform to ASTM A193/A193M, Grade 8 KS D 3755.

2.14.3 Nuts

Carbon steel nuts shall conform to ASTM A563, Grade A, hex style, hot-dipped galvanized. Stainless steel nuts shall conform to ASTM A194/A194M, Grade 8.

2.14.4 Washers

Provide flat circular washers under each bolt head and each nut. Washer materials shall be the same as the connecting bolt and nut. Carbon steel washers shall conform to ASTM F844, hot-dipped galvanized. Stainless steel washers shall conform to ASTM A194/A194M, Grade 8.

2.14.5 Polytetrafluoroethylene (PTFE) Tape

Tape shall conform to ASTM D3308.

2.14.6 Street Manway Assembly

Round street manhole frames and covers shall be the straight traffic type. Frames and covers shall be constructed of cast steel in accordance with ASTM A27/A27M, grade 60-30 as a minimum, cast iron in accordance with ASTM A48/A48M aluminum in accordance with ASTM B26/B26M or a engineered lightweight laminate material . Covers shall be the solid plate type with a checker pattern. Covers shall form a watertight seal with the manhole frame to prevent surface water inflow. Frame and cover assembly shall be rated to withstand H-20 highway loading as defined by AASHTO HB-17.

2.15 FINISHES

2.15.1 Factory Coating

Unless otherwise specified, provide equipment and components fabricated from ferrous metal with the manufacturer's standard factory finish. Each factory finish shall withstand 125 hours exposure to the salt spray test specified in ASTM B117. For test acceptance, the test specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark immediately after completion of the test. For equipment and component surfaces subject to temperatures above 50 degrees C (120 degrees F), the factory coating shall be appropriately designed for the temperature service.

PART 3 EXECUTION

3.1 INSTALLATION

Install work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Handle storage tanks with extreme care to prevent damage during placement and install in accordance with the manufacturer's installation instructions and NFPA 30 or NFPA 30A, as applicable. Inspect the exterior surface of each tank for obvious visual damage prior to and during the placement of each storage tank. Repair surface damage to a storage tank according to manufacturer's requirements before proceeding with the system installation. Provide the termination of fill lines within a tank with an antisplash deflector. Provide nylon dielectric bushings on pipe connections to a steel tank.

3.1.1 Underground Storage Tank

Install underground storage tanks in accordance with API RP 1615 except as modified herein. Place tank on a 3 mm per 30 mm (1/8 inch per foot) slope with the fill point at the low end and the vent connection at the high end. Locate tank so that the fuel discharge pipes slope up uniformly toward the fuel outlet. Install containment sumps prior to any backfill being added above the storage tanks.

3.1.1.1 Steel Tank Handling

Store, handle, and place externally coated steel tanks with care and in a manner that will minimize damage to the coating and will not reduce its protective value. Place coated tanks in position carefully and with a minimum of handling. Prior to backfilling a tank, visually inspect the tank exterior protective coating for damage. Repair any damaged tank coating in accordance with the appropriate UL or STI standard (UL 1746, STI F894, or STI P3).

3.1.1.2 Steel Tank Installation Procedures

Set tank on a minimum of 150 mm (6 inches) of backfill material. Anchor tank to a reinforced concrete anchor pad as indicated using manufacturer's supplied holddown straps. Separate tank from an anchor pad by a minimum of 300 mm (12 inches) of backfill material. Coat metal straps, turnbuckles, anchors, and accessories to resist corrosion. Uniformly place backfill material around the entire tank and extend to grade level. Inspect tank cathodic protection anodes, if applicable, to ensure integrity during backfill operations.

3.1.1.3 FRP Tank Handling

Handle tank with extreme care to prevent damage during installation and transportation to the site. Any damaged tank shall be replaced or repaired and tested under direct supervision and advice of the tank manufacturer, using the manufacturer's written procedures.

3.1.1.4 FRP Tank Installation Procedures

Set tank on a minimum of 150 mm (6 inches) of backfill material. Anchor tank to a reinforced concrete anchor pad as indicated through the use of manufacturer's supplied holddown straps. Separate tank from an anchor pad by a minimum of 300 mm (12 inches) of backfill material.

3.1.2 Equipment

Properly level, align, and secure equipment in place in accordance with manufacturer's instructions. Provide supports for equipment, appurtenances, and pipe as required. Install anchors, bolts, nuts, washers, and screws where required for securing the work in place. Sizes, types, and spacings of anchors and bolts not indicated or specified shall be as required for proper installation.

3.2 FIELD QUALITY CONTROL

3.2.1 Aboveground Storage Tank Tightness Tests

Perform tightness tests on each aboveground storage tank prior to making piping connections. Perform testing in accordance with STI R912 except as modified herein. Gauges used to monitor the tests shall have a scale with a maximum limit of 69 kPa (10 psig). Repair leaks discovered during the tightness tests in accordance with tank manufacturer's instructions. Following any repair, re-test the tank until the tank successfully passes the testing requirements of this paragraph.

3.2.2 Underground Storage Tank Tightness Tests

Perform a tightness test on each underground storage tank on-site just prior to their placement into the ground. Pneumatically pressurize each storage tank's primary chamber to 35 kPa (5 psig) and monitor for a drop in pressure over a 2-hour period during which there shall be no drop in pressure in the tank greater than that allowed for thermal expansion and contraction. Following the successful completion of the primary chamber test, bleed the pressure from the primary chamber into the interstitial space. Maintain this pressure while applying soapsuds or equivalent material over the exterior of the tank. While applying the soapsuds, visually inspect the entire tank, including the bottom surfaces, for leaks (bubble formations). Inspection of the bottom surfaces of a tank may be performed by rotating the tank; however a tank shall only be rotated in strict accordance with the manufacturer's recommendations. Do not rotate a tank more than 90 degrees from the upright position. During testing, install a pressure relief device that relieves at the tank manufacturer's suggested pneumatic pressure limit. Gauges used in pneumatic tests shall have a scale with a maximum limit of 69 kPa (10 psig).

3.2.2.1 Brine Level Test

In lieu of the pneumatic testing procedures described above, a brine level test may be performed on the interstitial space of double-walled FRP tanks (not applicable to steel tanks). For a brine level test, completely fill a FRP tank's interstitial space with a brine solution. Connect a riser pipe to the interstitial space that will allow the solution to rise up within the riser at least 300 mm (12 inches). After filling the interstitial space, the tank shall set approximately 3 hours. Following the 3-hour period, measure and record the level of solution within the riser. After a subsequent 4-hour period, again measure and record the level of solution within the riser. If the level of solution within the interstitial decreases anytime during the test, the tank is considered leaking and therefore fails the test.

3.2.2.2 Repairs

Repair leaks discovered in either the primary chamber or the interstitial space in accordance with the tank manufacturer's instructions. Following any tank repairs, re-test the tank until the tank successfully passes the testing requirements defined herein.

3.2.3 Tank Manufacturer's Tests

In addition to the tests required herein, perform any additional tests (i.e., leak tests, cathodic protection verification tests, etc.) on each storage test that is required by the tank manufacturer's written test procedures. Manufacturer's tests that are redundant to tests already required by this specification will only be performed once per tank. Repair all leaks discovered during the tests in accordance with manufacturer's instructions. Following tank repairs, re-test the tank until the tank successfully passes the manufacturer's testing requirements.

3.2.4 System Commissioning

System commissioning shall conform to Section 33 08 55 COMMISSIONING OF FUEL FACILITY SYSTEMS.

3.3 DEMONSTRATIONS

Conduct a training session for designated Government personnel in the operation and maintenance procedures related to the equipment/systems specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/equipment/systems, both operational and practical theories, and associated routine maintenance procedures. The training session shall consist of a total of 16 hours of normal working time and shall start after the system is functionally completed, but prior to final system acceptance. Submit a letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the onsite training.

3.4 Tank Fill Tests

Tank fill tests shall not be performed until after the flushing, cleaning, and adjusting requirements defined in Section 33 08 55 COMMISSIONING OF FUEL FACILITY SYSTEMS. For the tank fill tests, initially fill each storage tank with fuel in order to verify the tank level alarm system operates properly and the tank overfill protection device functions as designed. Stop filling each tank immediately once the overfill devices operates. Do not overfill any storage tank more than the 98 percent level. Drain the system below the low liquid level setpoint to verify operation of the low level alarm. Correct and retest any problems with the level alarm system or the overfill device until each operate as specified herein. During the tests, verify that all tank gauges are calibrated and operating appropriately.

3.5 FIELD PAINTING

Painting required for surfaces not otherwise specified shall be field painted as specified in Section 09 90 00 PAINTING, GENERAL. Do not paint stainless steel and aluminum surfaces. Do not coat equipment or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

-- End of Section --

SECTION 33 58 00

LEAK DETECTION FOR FUELING SYSTEMS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 1130	(2007) Computational Pipeline Monitoring for Liquid Pipelines
API RP 2003	(2008; 7th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 540	(1999; R 2004) Electrical Installations in Petroleum Processing Plants

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1100	(2005) Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment
IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 407	(2012; TIA 11-1) Standard for Aircraft Fuel Servicing
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 77	(2007) Recommended Practice on Static

	Electricity
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Leak Detection System; G
Electronic Monitoring/Alarm Panel
Computational Pipeline Monitoring System

SD-03 Product Data

Leak Detection System; G
Electronic Monitoring/Alarm Panel
Computational Pipeline Monitoring System

SD-06 Test Reports

Leak Detection System Test

SD-07 Certificates

Demonstrations

SD-08 Manufacturer's Instructions

Leak Detection System

SD-10 Operation and Maintenance Data

Leak Detection System
Electronic Monitoring/Alarm Panel
Computational Pipeline Monitoring System

1.3 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship, and that have been in satisfactory commercial or industrial use for a minimum 2 years prior to bid opening. The 2 year period shall include applications of the equipment and materials under similar circumstances and of similar size. Materials and equipment must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.

2.1.1 Nameplates

Attach nameplates to all specified equipment defined herein. List on each nameplate the manufacturer's name, address, contract number, acceptance date, component type or style, model or serial number, catalog number, capacity or size, and the system which is controlled. Construct plates of anodized aluminum, stainless steel, or melamine plastic, 3 mm (0.125 inch) thick, UV resistance, black with white center core, matte finish surface and square corners . Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates shall be 25 by 65 mm (1.0 by 2.5 inches). Lettering shall be the normal block style with a minimum 6 mm (0.25 inch) height. Accurately align all lettering on nameplates. For plastic nameplates, engrave lettering into the white core. Key the nameplates to a chart and schedule for each system. Frame charts and schedule under glass, and locate where directed near each system. Furnish two copies of each chart and schedule. Each nameplate description shall identify its function.

2.1.2 Metallic Requirements

Internal parts and components of equipment, piping, piping components, and valves that could be exposed to fuel during system operation shall not be constructed of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.2 ELECTRICAL WORK

Provide controllers, integral disconnects, contactors, controls, and control wiring with their respective pieces of equipment. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide switches and devices necessary for controlling and protecting electrical equipment. Controllers and contactors shall have a maximum of 120-volt control circuits and shall have auxiliary contacts for use with the controls provided.

2.2.1 Underground Wiring

Enclose underground electrical wiring in PVC coated conduit. Dielectrically isolate conduit at any steel storage tank connection.

2.2.2 Grounding and Bonding

Grounding and bonding shall be in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.3 LEAK DETECTION SYSTEM

Provide a system, including sensors and detectors, that is intrinsically safe for use in a Class 1, Division 1, Group D environment as defined by NFPA 70. System shall be compatible with the fuel to be handled. Sensors shall distinguish and report the difference between hydrocarbons and water. Output and transmission from sensors and detectors shall be electronic. Sensors shall have a minimum probability of detection of 95 percent and a maximum probability of false alarm of 5 percent. Sensors and detectors shall be compatible with the electronic monitoring/alarm panel. Sensors shall be reusable after an alarm condition is sensed. Submit shop drawings for the leak detection system that include the following.

a. Wiring schematics for all parts of the system showing each operating device and listing their normal ranges of operating values (including pressures, temperatures, voltages, currents, speeds, etc.).

b. Single line diagrams of the entire system.

c. Diagrams for posting that include distance markings such that alarm indications can be correlated to leak location in plan view. The diagrams shall include a piping and wiring display map with schematic diagrams from the leak detection system manufacturer. The diagrams shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

2.3.1 Underground Storage Tanks

System shall continuously and automatically monitor the interstitial space of an underground tank for breaches in the integrity of the inner and/or outer tank shells. Monitor the interstitial space by using either an electronic capacitance type liquid sensor or a positive pressure system. Monitoring the interstitial space of a fiberglass reinforced plastic (FRP) tank may be performed using a liquid-filled interstitial space monitoring system. The liquid solution used in a liquid-filled interstitial shall be freeze protected (brine) and shall contain appropriate corrosion inhibitors. The monitoring system shall detect and discriminate between high and low brine level conditions.

2.3.2 Aboveground Vaulted Storage Tanks

System shall continuously and automatically monitor the interstitial space of a vaulted tank for breaches in the integrity of the primary tank and the exterior vaulted shell. Monitor the interstitial space with electronic capacitance type liquid sensors.

2.3.3 Underground Piping

System shall continuously and automatically monitor for piping leaks using an automatic line leak detector. Detector shall detect a minimum leak rate of 0.003 L/s (3 gallons per hour) at 69 kPa (10 psig) line pressure within 1 hour. Detector shall detect leaks against a minimum 1.8 m (6 feet) of head pressure. Detector shall detect leaks from any portion of the underground product piping.

2.3.4 Containment Sumps

System shall continuously and automatically monitor each containment sump and dispenser sump with an electronic capacitance type liquid sensor. Sensor shall detect liquids within a minimum of 25 mm (1 inch) above a sump's bottom.

2.3.5 Monitoring Wells

System shall continuously and automatically monitor each monitoring well with a hydrocarbon/groundwater or vapor sensor, as indicated. Hydrocarbon/groundwater sensor shall distinguish the difference between hydrocarbons and water while totally immersed in groundwater. Sensor shall sense when the groundwater level has reached a minimum definable setpoint. Vapor sensor shall detect vapors of the fuel to be handled as well as sense the presence of liquid.

2.4 ELECTRONIC MONITORING/ALARM PANEL

Panel shall perform continuous integrity checks on the status of each sensor's connections and wiring. Panel shall include a battery backup (rechargeable) that can operate the complete leak detection system during a power failure for a minimum period of 48 hours. Submit shop drawings of the panel layout along with panel mounting and support details. Panel shall be compatible with and connected to the following:

a. Tank interstitial sensors and detectors.

b. Sump sensors and detectors.

c. Automatic line leak detectors.

d. Monitoring well sensors and detectors.

e. Digital tank gauge system as defined in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.4.1 Panel Housing

Panel housing shall be a NEMA 4 rated enclosure in accordance with NEMA 250 , unless otherwise indicated. Panel housing shall have a hinged door to swing left or right (doors shall not swing up or down).

2.4.2 Panel Alarms

Panel shall account for the effects of thermal expansion or contraction of the fuel product, vapor pockets, tank or piping deformation, evaporation or condensation, as well as groundwater levels (if applicable) prior to initiating an alarm condition. Panel shall produce an audible and visual alarm in the event any of the following occur.

a. Sensing of a hydrocarbon liquid from a sensor or detector.

b. Sensing of a hydrocarbon vapor from a sensor or detector.

c. Sensing of water from a sensor or detector.

d. Failure of an automatic line leak test.

e. Loss of pressure in positively pressurized tank interstitial.

f. Sensing a high or low liquid level in liquid-filled tank interstitial.

g. Sensing minimum groundwater setpoint.

h. Failure of any integrity check.

i. Sensing tank high, high-high, or low level alarm conditions.

2.4.2.1 Audible Alarm

Panel shall have internal and external speakers that produce a buzzer sound of 70 decibels or greater in the event of a detected alarm condition.

2.4.2.2 Visual Alarm

Panel shall have a visual alarm that illuminates in the event of a detected alarm condition. Visual alarm shall include either individual lights for each alarm condition or shall include a single light and a liquid crystal display (LCD) panel that displaces information regarding each alarm condition.

2.4.3 Acknowledge Switch

Panel shall have a manual acknowledge switch that will deactivate the audible alarm. Acknowledge switch shall not deactivate subsequent audible alarms unless depressed manually again for each occurrence. Under no circumstance shall this acknowledgement switch extinguish the visual alarms until the alarm condition has been corrected. Switches shall be an integral component located on the front panel and be either a key switch or push button.

2.5 COMPUTATIONAL PIPELINE MONITORING SYSTEM

CPM system shall conform to API RP 1130. System shall detect leaks as small as 0.004 percent of the pipeline volume within 1 hour. System shall account for thermal effects on the piping and fuel. System shall be compatible with the fuel to be handled. System shall be provided as a complete, portable system, unless otherwise indicated.

2.6 FINISHES

2.6.1 Factory Coating

Unless otherwise specified, provide equipment and components fabricated from ferrous metal with the manufacturer's standard factory finish. Each factory finish shall be capable of withstanding 125 hours exposure to the salt spray test specified in ASTM B117. For test acceptance, the test specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark immediately after completion of the test. For equipment and component surfaces subject to temperatures above 50 degrees C (120 degrees F), the factory coating shall be appropriately designed for the temperature service.

2.6.2 Field Painting

Painting required for surfaces not otherwise specified shall be field painted as specified in Section 09 90 00 PAINTING, GENERAL. Do not paint stainless steel and aluminum surfaces. Do not coat equipment or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

PART 3 EXECUTION

3.1 INSTALLATION

Install parts requiring periodic inspection, operation, maintenance, and repair in locations that allow ready access. Install leak detection system and components in accordance with manufacturer's installation instructions.

3.1.1 Storage Tank Sensors/Detectors

Install interstitial tank sensors and detectors at the tank's low end. Sensor installation shall be in accordance with the tank manufacturer's recommendations and shall not compromise the tank's secondary containment in any manner. Sensors shall be easily removed from a tank. Connection of metal conduit to steel tanks shall be with dielectric fittings.

3.1.2 Automatic Line Leak Detector

Install detector on discharge side of each submersible pump in accordance with the pump and detector manufacturer's recommendations.

3.1.3 Sensors in Sumps

Install sensors in the low point of a sump in accordance with sump and sensor manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

3.2.1 Leak Detection System Test

Activate and test the entire leak detection system in accordance with manufacturer's testing procedures. Use the electronic monitoring/alarm panel to record and present the results.

3.2.2 Storage Tank Tightness Tests

Storage tank tightness tests shall be performed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS. Use the electronic monitoring/alarm panel to record and present the results.

3.2.3 Tank Fill Tests

High liquid level alarm tests on storage tanks shall be performed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS. Use the electronic monitoring/alarm panel to record and present the results.

3.3 DEMONSTRATIONS

Conduct a training session for designated Government personnel in the operation and maintenance procedures related to the equipment/systems specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/equipment/systems, both operational and practical theories, and associated routine maintenance procedures. The training session shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed, but prior to final system acceptance. Submit a letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the onsite training.

-- End of Section --

SECTION 33 70 02.00 10

ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1	(2008) Wood Poles -- Specifications & Dimensions

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC C8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV
AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire
ASTM B496	(2004e1; R 2010) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C478	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections

ASTM C478M	(2012) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D2472	(2000; R 2006) Standard Specification for Sulphur Hexafluoride
ASTM D4059	(2000; R 2010) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography
ASTM D923	(2007) Standard Practice for Sampling Electrical Insulating Liquids

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code

IEEE C37.04	(1999; R 2006; AMD 1 2003; R 2006; ERTA 2005; R 2006; AMD 2 2008; CORR 2009; INT 2010) Standard for Rating Structure for AC High-Voltage Circuit Breakers
IEEE C37.1	(2007) Standard for Supervisory Control, Data Acquisition (SCADA) and Automatic Systems
IEEE C37.121	(1989; R 2006) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C37.13	(2008; INT 1 2009; AMD 1 2012) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.16	(2009) Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers
IEEE C37.2	(2008) Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations
IEEE C37.20.1	(2002; INT 1 2005; AMD A 2005; AMD B 2006; R 2007) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.20.2	(1999; Corr 2000; R 2005) Standard for Metal-Clad Switchgear
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE C37.23	(2003; R 2008) Standard for Metal-Enclosed Bus
IEEE C37.30	(1997; INT 1 2011) Standard Requirements for High-Voltage Switches
IEEE C37.34	(1994) Standard Test Code for High-Voltage Air Switches
IEEE C37.40	(2003; Errata 2003; R 2009) Service Conditions & Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, & Accessories
IEEE C37.41	(2008; Errata 2009) Standard Design Tests for High-Voltage (>1000 V) Fuses, Fuse and Disconnecting Cutouts, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

	Used with These Devices
IEEE C37.46	(2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C37.63	(2005) Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C37.90.1	(2012) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.21	(1992) Pad-Mounted, Compartmental-Type Self-Cooled, Single-Phase Distribution Transformers With High Voltage Bushings; High-voltage, 34,500 GRYD/19,920 Volts
IEEE C57.12.26	(1992) Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60255-21-3	(1993) Electrical Relays - Part 21: Vibration, Shock, Bump And Seismic Tests On Measuring Relays And Protection Equipment - Section 3: Seismic Tests; Ed 1.0

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts

ANSI C29.1	(1988; R 2002) American National Standard for Electrical Power Insulators--Test Methods
ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less
NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA C37.50	(2012) American National Standard for Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures
NEMA FB 1	(2012) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA LA 1	(2009) Standard for Surge Arresters
NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA SG 2	(1993) Standard for High-Voltage Fuses
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 7	(2005) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Aug 2011) Medium-Voltage Power Cables
UL 1684	(2000; Reprint Aug 2009) Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
UL 198M	(2003; Reprint Feb 2013) Standard for Mine-Duty Fuses
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 489	(2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables
UL 857	(2009; Reprint Dec 2011) Busways

1.2 SYSTEM DESCRIPTION

Items provided under this section shall be specifically suitable for the service conditions as discussed in the references listed in the table below and as indicated on contract drawings and documents. Seismic details shall conform to UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

ITEM OF EQUIPMENT	STANDARD
Instrument Transformers	IEEE C57.13
Switchgear	IEEE C37.20.1 IEEE C37.20.2 IEEE C37.20.3

ITEM OF EQUIPMENT	STANDARD
Power Circuit Breakers (Above 1000 Volts)	IEEE C37.04
Molded-Case Circuit Breakers	IEEE C37.13
Relays, Electrical Power Apparatus	IEEE C37.90
Surge Arrestors	IEEE C62.11
Switches	IEEE C37.30 IEEE C37.40
Transformers	IEEE C57.12.00
Switchboards	NEMA PB 2

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G
As-Built Drawings

SD-03 Product Data

Fault Current Analysis; G
Protective Device; G
Coordination Study; G
Material and Equipment
Installation Requirements

SD-06 Test Reports

Factory Tests
Field Testing
Operating Tests
Cable Installation
Study Report

SD-07 Certificates

Material and Equipment
Cable Joints
Installation Engineer

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

1.4.1 Detail Drawings

Submit detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams manufacturers standard installation drawings and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

a. If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be included with the detail drawings. Approved departures shall be made at no additional cost to the Government.

b. Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

(1) Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. All optional items shall be clearly identified as included or excluded.

(2) Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

(3) Detail drawings shall as a minimum depict the installation of the following items:

(a) Medium-voltage cables and accessories including cable installation plan.

(b) Transformers.

(c) Substations.

(d) Switchgear.

(e) Pad-mounted loadbreak switches.

(f) Busways.

(g) Surge arresters.

1.4.2 As-Built Drawings

The as-built drawings shall be a record of the construction as installed.

The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURESThe as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, provide one hard copy & one digital copy marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. Correct and return the as-built drawings to the Contracting Officer for approval within 10 calendar days from the time the drawings are returned to the Contractor.

1.5 DELIVERY, STORAGE, AND HANDLING

Visually inspect devices and equipment when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Store oil filled transformers and switches in accordance with the manufacturer's requirements. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ATIS ANSI O5.1. Handle wood poles in accordance with ATIS ANSI O5.1, except that pointed tools capable of producing indentations more than 25 mm (1 inch) in depth shall not be used. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.6 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the contracting officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

a. Submit a complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item.

b. Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), submit proof that the items provided conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms.

c. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies. Compliance with above-named requirements does not relieve the Contractor from compliance with any other requirements of the specifications.

2.2 NAMEPLATES

Submit catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

2.2.1 General

Each major component of this specification shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Nameplates shall be made of noncorrosive metal. Equipment containing liquid dielectrics shall have the type of dielectric on the nameplate. Sectionalizer switch nameplates shall have a schematic with all switch positions shown and labeled. As a minimum, nameplates shall be provided for transformers, circuit breakers, meters, switches, and switchgear.

2.2.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with nameplate information in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters (gallons) and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 2 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 2 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.3 CORROSION PROTECTION

2.3.1 Aluminum Materials

Aluminum shall not be used.

2.3.2 Ferrous Metal Materials

2.3.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A153/A153M and ASTM A123/A123M.

2.3.2.2 Equipment

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.3.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

2.4 CABLES

Cables shall be single conductor type unless otherwise indicated.

2.4.1 Medium-Voltage Cables

2.4.1.1 General

Cable construction shall be Type MV, conforming to NFPA 70 and UL 1072 . Cables shall be manufactured for use in duct or direct burial applications as indicated.

2.4.1.2 Ratings

Cables shall be rated for a circuit voltage as indicated.

2.4.1.3 Conductor Material

Underground cables shall be soft drawn copper complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.4.1.4 Insulation

Cable insulation shall be ethylene-propylene-rubber (EPR) insulation conforming to the requirements of AEIC CS8 . A 133 percent insulation level shall be used on 5 kV, 15 kV and 25 kV rated cables.

2.4.1.5 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper wire shield for each phase. The shield wire shall be #2/0 AWG bare copper ground conductor or sized to meet IEEE C2 requirements for a ground fault current availability as indicated on contract drawings and documents.

2.4.1.6 Jackets

Cables shall be provided with a PVC or polyethylene jacket. Direct buried cables shall be rated for direct burial.

2.4.2 Low-Voltage Cables

Cables shall be rated 600 volts and shall conform to the requirements of NFPA 70, and must be UL listed for the application or meet the applicable section of either ICEA or NEMA standards.

2.4.2.1 Conductor Material

Underground cables shall be annealed copper complying with ASTM B3 and ASTM B8. Intermixing of copper and aluminum conductors is not permitted.

2.4.2.2 Insulation

Insulation must be in accordance with NFPA 70, and must be UL listed for the application or meet the applicable sections of either ICEA, or NEMA standards.

2.4.2.3 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

2.4.2.4 Direct Buried

Single and multi-conductor cables shall of a type identified for direct burial. Service entrance cables shall conform to UL 854 for Type USE service entrance cable.

2.4.2.5 In Duct

Cables shall be single-conductor cable, in accordance with NFPA 70. Cables in factory-installed, coilable-plastic-duct assemblies shall conform to NEMA TC 7.

2.5 CABLE JOINTS, TERMINATIONS, AND CONNECTORS

2.5.1 Medium-Voltage Cable Joints

Medium-voltage cable joints shall comply with IEEE 404. Medium-voltage cable terminations shall comply with IEEE 48. Joints shall be the standard products of a manufacturer and shall be either of the factory preformed type or of the kit type containing tapes and other required parts. Joints shall have ratings not less than the ratings of the cables on which they are installed. Splice kits may be of the heat-shrinkable type for voltages up to 15 kV, of the premolded splice and connector type, the conventional taped type, or the resin pressure-filled overcast taped type for voltages up to 35 kV; except that for voltages of 7.5 kV or less a resin pressure-filled type utilizing a plastic-tape mold is acceptable. Joints used in manholes, handholes, vaults and pull boxes shall be certified by the manufacturer for waterproof, submersible applications.

2.5.2 Medium-Voltage Separable Insulated Connectors

Separable insulated connectors shall comply with IEEE 386 and shall be of suitable construction or standard splice kits shall be used. Separable insulated connectors are acceptable for voltages up to 35 kV. Connectors shall be of the loadbreak type as indicated, of suitable construction for the application and the type of cable connected, and shall include cable shield adaptors. Separable insulated connectors shall not be used as substitutes for conventional permanent splices. External clamping points and test points shall be provided.

2.5.3 Low-Voltage Cable Splices

Low-voltage cable splices and terminations shall be rated at not less than 600 Volts. Splices in conductors No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. Splices in conductors No. 8 AWG and larger shall be made with noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. Splices shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

2.5.4 Terminations

Terminations shall be in accordance with IEEE 48, Class 1 or Class 2; of the molded elastomer, wet-process porcelain, prestretched elastomer, heat-shrinkable elastomer, or taped type. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations shall be of the outdoor type, except that where installed inside outdoor equipment housings which are sealed against normal infiltration of moisture and outside air, indoor, Class 2 terminations are acceptable. Class 3 terminations are not acceptable. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, and armor.

2.5.4.1 Factory Preformed Type

Molded elastomer, wet-process porcelain, prestretched, and heat-shrinkable terminations shall utilize factory preformed components to the maximum extent practicable rather than tape build-up. Terminations shall have basic impulse levels as required for the system voltage level. Leakage distances shall comply with wet withstand voltage test requirements of IEEE 48 for the next higher Basic Insulation Level (BIL) level. Anti-tracking tape shall be applied over exposed insulation of preformed molded elastomer terminations.

2.5.4.2 Taped Terminations

Taped terminations shall use standard termination kits providing terminal connectors, field-fabricated stress cones, and rain hoods. Terminations shall be at least 510 mm (20 inch) for 15 KV cable, 635 mm (25 inch) for 25 KV long from the end of the tapered cable jacket to the start of the terminal connector, or not less than the kit manufacturer's recommendations, whichever is greater.

2.6 CONDUIT AND DUCTS

Duct lines shall be nonencased direct-burial, thick-wall type or concrete-encased, thin-wall type for duct lines between manholes and for other medium-voltage lines. Low-voltage lines or communication lines run elsewhere may be direct-burial, thick-wall type. Where concrete encasement is not required, low-voltage circuits may utilize factory-installed cable in coilable plastic duct.

2.6.1 Metallic Conduit

Rigid galvanized steel conduit shall comply with UL 6 and ANSI C80.1 or KS C 8401. Metallic conduit fittings and outlets shall comply with UL 514A and NEMA FB 1 or KS C 8460, KS C 8461.

2.6.2 Nonmetallic Ducts

2.6.2.1 Bituminized Fiber Duct

UL 1684 for Type I (Thinwall) or Type II (Thickwall).

2.6.2.2 Concrete Encased Ducts

UL 651 Schedule 40 or NEMA TC 6 & 8 Type EB, or KS C 8431 high impact type.

2.6.2.3 Direct Burial

UL 651 Schedule 40 and Schedule 80 as indicated, or NEMA TC 6 & 8 Type DB or KS C 8431 high impact type.

2.6.3 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C (35 degrees F), shall neither slump at a temperature of 150 degrees C (300 degrees F), nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials.

2.7 MANHOLES, HANDHOLES, AND PULLBOXES

Manholes, handholes, and pullboxes shall be as indicated. Strength of manholes, handholes, and pullboxes and their frames and covers shall conform to the requirements of IEEE C2. Precast-concrete manholes shall have the required strength established by ASTM C478, ASTM C478M. Frames and covers shall be made of gray cast iron and a machine-finished seat shall be provided to ensure a matching joint between frame and cover. Cast iron shall comply with ASTM A48/A48M, Class 30B, minimum. Handholes for low voltage cables installed in parking lots, sidewalks, and turfed areas shall be fabricated from an aggregate consisting of sand and with continuous woven glass strands having an overall compressive strength of at least 69 MPa (10,000 psi) and a flexural strength of at least 34.5 MPa (5,000 psi). Pullbox and handhole covers in sidewalks, and turfed areas shall be of the same material as the box. Concrete pullboxes shall consist of precast reinforced concrete boxes, extensions, bases, and covers.

2.8 POLES AND HARDWARE

Poles and hardware shall be in accordance with Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

2.9 TRANSFORMERS, SUBSTATIONS, AND SWITCHGEAR

Transformers, substations, and switchgear shall be of the outdoor type having the ratings and arrangements indicated. Medium-voltage ratings of cable terminations shall be 133 percent insulation level.

2.9.1 Secondary Unit Substation

Secondary unit substations shall comply with IEEE C37.121. Substations shall be assembled and coordinated by one manufacturer and shall be shipped in complete sections ready for connection at the site. Complete sections shall include incoming, transformer, and outgoing sections and, where practicable, shall be shipped as one unit.

2.9.1.1 Incoming Section

Metal-enclosed interrupter switchgear consisting of fused, vacuum- or SF6-insulated as indicated on contract drawings and documents, interrupters in series with automatic, visible blade disconnects shall be provided for protection of incoming circuits. SF6 gas shall conform to ASTM D2472. Metal-enclosed interrupter switchgear shall comply with IEEE C37.30 for load-interrupter switches, NEMA SG 2 for power fuses, and shall be of the outdoor no-aisle type that meets or exceeds the requirements of applicable publications listed. Switch construction shall be of the manually-operated, "OPEN-CLOSED," vacuum- or SF6-insulated, load interrupter type equipped with a stored energy operator for quick-make quick-break to make operating speeds independent of manual switch operations. Where indicated, suitable bus or lug connections shall be provided to mount field-installed, slip-on, medium-voltage cable terminations for cable entering via conduit from below and a flanged throat suitable for direct connection to the associated transformer and a bus throat suitable for connection to the associated metal-enclosed bus. Surge protection shall be provided in accordance with paragraph SURGE ARRESTERS. Switches shall be of the 2-position type, open-closed. Selector switches shall be of the single-compartment, 3-position type, Line 1 - Open - Line 2, consisting of an interrupter switch in series with a selector switch. Duplex switches shall be of the dual compartment type with 2 interrupter switches.

a. Ratings. Fuse continuous current ratings shall be as indicated for the transformer for an incoming line unit and for the line tie unit. Unless otherwise indicated, fuses shall be of the current limiting type. Following switch ratings at 60 Hz shall be as indicated on contract drawings and documents:

Nominal voltage
Rated maximum voltage

Maximum symmetrical interrupting capacity
Maximum asymmetrical interrupting capacity
3-Second short time current carrying capacity
Rated continuous current
BIL

b. Basic Requirements. The electrical devices listed below shall be rated for the application and voltage and current indicated. Unless otherwise noted, manufacturer's standard devices shall be provided and shall include the following:

(1) A switch-operating handle with provisions for locking in either the open or closed position.

(2) A switch mechanical position indicator.

(3) A heater continuously energized to prevent condensation over an ambient temperature range of minus 29 degrees C to 40 degrees C (minus 20 degrees F to 40 degrees F) at 90% relative humidity and wired in series with a cabinet door-actuated switch, so the heater is de-energized when doors are open. High-temperature thermal protection shall be included.

(4) One-pole or 2-pole thermal-magnetic, molded-case circuit breakers suitable for the operating voltage for heater circuits.

(5) Safety devices as necessary to ensure that the load interrupter switch is in the open position whenever unit doors are in the open position.

(6) A key interlock if indicated.

(7) An interface terminal block wired for required exterior connections.

2.9.1.2 Transformer Section

Transformers shall have two separate windings per phase and shall be of the mineral oil-insulated or less-flammable, liquid-insulated type with high molecular-weight hydrocarbon or dimethyl silicone liquid. Transformers shall be suitable for outdoor use. Liquid-insulated transformers shall comply with IEEE C57.12.00, and shall have two 2-1/2 percent full capacity taps above and two 2-1/2 percent full capacity taps below rated voltage. Transformers shall be of the sealed tank type construction with welded-on cover. High-voltage terminals shall be provided for direct connection to the incoming line section as shown on the drawings. Low-voltage terminals shall be provided for direct connection to the outgoing switchgear section or bus duct as shown on the drawings. Low-voltage terminals shall be as shown on the drawings when facing the front, accessory side of the transformer. Transformers shall be equipped with forced air cooling equipment capacity as required for specified KVA. The equipment shall include the necessary fans, conduit and wiring, motor starters, and top liquid thermometer for fan control. Provision shall be made for the future addition of forced air cooling equipment to give required increased kVA capacity. The transformer bushings, leads, and other components shall be designed to carry the increased load. A top liquid thermometer for control of future fans shall be furnished. Provision for future mounting of fans, conduit, and terminal box shall be provided. Transformer ratings at 60 Hz shall be as follows or as indicated on contract drawings and documents.

1. Three-phase capacity, self-cooled (kVA)

2. Three-phase capacity, (future) forced-cooled(kVA)

3. Impedance. 5.75 percent (standard) unless otherwise indicated.

4. Temperature rise. 55/65 degrees C, unless otherwise indicated.

5. High-voltage winding (volts).

6. High-voltage winding connection.

7. Low-voltage winding (volts).

8. Low-voltage winding connection.

Accessories:

1. drain and filter connection.

2. filling and top filter press connection.

3. pressure-vacuum gauge.

4. dial type thermometer with alarm contacts.

5. magnetic liquid level indicator with high and low level alarm contacts.

6. pressure relief device with alarm contacts.

7. ground connection pad.

8. provision for jacking, lifting, and towing.

9. diagram and rating nameplate.

2.9.1.3 Integral Outgoing Section

Integral outgoing section shall be of the busway throat compartment, dead-front distribution panelboard/switchboard, or metal-enclosed switchgear type as indicated on contract drawings and documents. Each circuit breaker and auxiliary compartment shall have a suitable metal or laminated plastic nameplate with white cut letters at least 6.4 mm (1/4 inch) high on contrasting backgrounds identifying the breaker unit and/or circuit number as shown on the drawings.

a. Busway Throat Compartment Type: Outgoing section shall consist of an enclosure containing metering devices on the main secondary circuit and connections from transformer terminals to suitable busway throats provided for connections to busway installations entering as shown. Connection to porcelain bushings shall be made with flexible jumpers.

b. Dead-Front Distribution Panelboard/Switchboard Type: Outgoing section shall be of the panelboard/switchboard type mounted integrally with the transformer and shall consist of metering devices and main and branch circuit breakers mounted in panelboard/switchboard enclosures. Panelboards shall comply with NEMA PB 1. Switchboards shall comply with NEMA PB 2. Molded-case and low-voltage power circuit breakers shall comply with paragraph METERING AND PROTECTIVE DEVICES. Plug-in type circuit breakers are not acceptable. Directories to indicate loads served by each circuit shall be typed and mounted in holders provided on panelboard doors behind protective coverings.

c. Metal-Enclosed Switchgear Type: Outgoing section shall be of the metal-enclosed drawout circuit breaker type, in accordance with IEEE C37.20.1. Low-voltage power circuit breakers shall comply with the requirements of paragraph METERING AND PROTECTIVE DEVICES.

d. Metering: The main secondary bus of each outgoing section assembly shall include a watthour demand meter with the necessary instrument transformers, and VT and CT test blocks. Metering shall be as specified in paragraph METERING AND PROTECTIVE DEVICES.

e. Ground Fault Protection: Ground fault protection shall be provided utilizing sensors of the zero-sequence type or by the residual connection of phase and neutral current sensors. Ground fault settings shall be as determined by the coordination study.

2.9.1.4 Nonintegral (Cable Compartment) Outgoing Section

A cable compartment shall be provided on the transformer for cable connections as shown. Clamp type terminations for cables shall be provided for connection to the transformer bushings. Clamp type cable terminations, suitable for copper or aluminum conductors, shall be provided for the circuit sizes shown to match circuit breakers.

2.9.2 Pad-Mounted Transformers

Pad-mounted transformers shall comply with IEEE C57.12.26 and shall be of the loop feed type. Pad-mounted transformer stations shall be assembled and coordinated by one manufacturer and each transformer station shall be shipped as a complete unit so that field installation requirements are limited to mounting each unit on a concrete pad and connecting it to primary and secondary lines. Stainless steel pins and hinges shall be provided. Barriers shall be provided between high- and low-voltage compartments. High-voltage compartment doors shall be interlocked with low-voltage compartment doors to prevent access to any high-voltage section unless its associated low-voltage section door has first been opened. Compartments shall be sized to meet the specific dimensional requirements of IEEE C57.12.26. Pentahead locking bolts shall be provided with provisions for a padlock.

2.9.2.1 High-Voltage Compartments

The high-voltage compartment shall be dead-front construction. Primary switching and protective devices shall include loadbreak switching, oil-immersed, bayonet-type, overload fuse in series with a partial range current-limiting fuse, medium-voltage separable loadbreak connectors, universal bushing wells and inserts or integral one piece bushings and surge arresters. Fuses shall comply with the requirements of paragraph

METERING AND PROTECTIVE DEVICES. The switch shall be mounted inside transformer tank with switch operating handle located in high-voltage compartment and equipped with metal loop for hook stick operation. Fuses shall be interlocked with switches so that fuses can be removed only when the associated switch is in the "OPEN" position. Adjacent to medium-voltage cable connections, a nameplate or equivalent stenciled inscription shall be provided inscribed "DO NOT OPEN CABLE CONNECTORS UNLESS SWITCH IS OPEN." Surge arresters shall be fully insulated and configured to terminate on the same bushing as the primary cable by means of a loadbreak, feed-through bushing insert.

2.9.2.2 Load-Break Switch

a. Radial-feed oil-immersed type voltage, BIL, continuous current, and load-break current ratings shall be as indicated on contract drawings and documents, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

b. Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch voltage and BIL rating shall be as indicated on contract drawings and documents, with a continuous current rating and load-break rating amperes as shown, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment. Operation of switches shall be as follows:

	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW		LINE B SW		XFMR SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
1	Line A connected to Line B and both lines connected to transformer		X		X		X
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to Line B only	X			X		X
4	Transformer open and loop closed		X		X	X	
5	Transformer open and loop open	X		X		X	

2.9.2.3 Transformer Tank Sections

Transformers shall comply with IEEE C57.12.00 and IEEE C57.12.21 andshall be of the mineral oil-insulated type or less-flammable, liquid-insulated type with high molecular-weight hydrocarbon or dimethyl silicone liquid. Transformers shall be suitable for outdoor use and shall have 2 separate windings per phase. Standard NEMA primary taps shall be provided. Where primary taps are not specified, 4, 2-1/2 percent rated taps shall be provided 2 above and 2 below for 480Y/277 volts secondary and 4 below for 208Y/120 volts secondary. Operating handles for primary tap changers for de-energized operation shall be located within high-voltage compartments, externally to transformer tanks. Adjacent to the tap changer operating handle, a nameplate or equivalent stenciled inscription shall be provided and inscribed "DO NOT OPERATE UNDER LOAD." Transformer ratings at 60 Hz shall be as follows or as indicated on contract drawings and documents.

Three-phase capacity	kVA
Impedance	5.75%, unless otherwise indicated on contract drawings and documents
Temperature Rise	65 degrees C (149 degrees F)
High-voltage winding	volts
High-voltage winding connections	
Low-voltage winding	volts
Low-voltage winding connections	

2.9.2.4 Low-Voltage Cable Compartments

Neutrals shall be provided with fully-insulated bushings. Clamp type cable terminations, suitable for copper conductors entering from below, shall be provided as necessary.

2.9.2.5 Accessories

High-voltage warning signs shall be permanently attached to each side of transformer stations. Voltage warning signs shall comply with IEEE C2. Copper-faced steel or stainless steel ground connection pads shall be provided in both the high- and low-voltage compartments. Dial-type thermometer, liquid-level gauge, and drain valve with built-in sampling device shall be provided for each transformer station. Insulated-bushing-type parking stands shall be provided adjacent to each separable load-break elbow to provide for cable isolation during sectionalizing operations.

2.9.3 Busways

Busways shall comply with NEMA BU 1.1 and UL 857 and shall be of the voltage, phase, and continuous current ratings indicated. Neutrals shall be full size. Busways shall have short-circuit ratings not less than the maximum short-circuit currents of associated transformers, assuming primary sources of infinite capacity. Busways shall be feeder-low-impedance type and of outdoor or indoor service construction as suitable to the location. Busways shall be complete with elbows, fittings, flanges, end-closures, tees, crosses, cable-tap boxes, accessories, and other devices required for the indicated installation, and shall be coordinated for connection to the indicated equipment. For wet/damp locations, bus duct shall be heated, nonventilated enclosure, nonsegregated phase type in accordance with IEEE C37.23. Detail drawings for busway supports and bracing shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS and shall indicate that busways are adequately supported for the seismic forces specified.

2.9.4 Pad-Mounted, Metal-Enclosed, Switchgear

The switchgear shall be configured with 2 incoming compartments for loop-feed arrangement , equipped with oil-insulated, load-interrupter switches , unless otherwise indicated on contract drawings and documents. The outgoing compartments shall be provided with fused disconnects or non-reclosing vacuum-type interrupters or circuit breakers as indicated.

2.9.4.1 Following ratings at 60 Hz shall be as indicated on contract drawings and documents:

Nominal voltage (kV)
Rated maximum voltage (kV)
Rated continuous current (A)
Maximum symmetrical interrupting capacity (kA)
Maximum asymmetrical interrupting capacity (kA)
Three-second short-time current-carrying capacity (kA)
BIL (kV)

2.9.4.2 Operators, Devices, and Controls

Operators and controls shall be provided for the switchgear as follows:

a. Switches shall be provided with a manual, handle-type operator or a push-button mechanical spring tripping mechanism, utilizing a stored-energy (spring-driven) mechanism to simultaneously open or close all phases. The switchgear shall be configured so that the switch actuator is padlockable, but may be accessed without opening the switch compartment doors.

b. Fused disconnects shall be hook-stick operated.

c. Switches shall be provided with an automatic switch operator configured for local and remote opening and closing. An actuator charging motor shall be provide which operates at 24 V dc or 120 V ac as indicated on contract drawings and documents. Switches shall be provided with remote telemetry units (RTUs) for remote operation and integration with supervisory, control, and data acquisition systems. Systems, components, and equipment shall conform to the requirements and recommendations of IEEE C37.1.

d. Vacuum type interrupters shall be provided with an electronic controller for trip initiation. Manual trip initiation shall be provided by a push button or switch. Automatic trip shall be initiated by detection of excessive current. The electronic controller shall provide trip current selection capability according to present time-current response curves, as indicated. Each interrupter shall be provided with a 3 phase, gang-operated handle mechanism for trip and reset.

2.9.4.3 Enclosures

Switchgear enclosures shall be of freestanding, self-supporting construction provided with separate incoming and outgoing compartments configured for bottom cable entry. Enclosures shall be of deadfront construction, provided with a hinged door for access to each compartment, and conform to the requirements of IEEE C57.12.28 and IEEE C37.20.3, Category A.

2.9.5 Pad-Mounted Sectionalizers

Pad-mounted, sectionalizing switches shall conform to the requirements of IEEE C37.63. The switchgear shall be configured with 2 incoming compartments for loop-feed arrangement equipped with oil-insulated, load-interrupters switches , as indicated. The outgoing compartments shall be provided with non-reclosing sectionalizers.

2.9.5.1 Ratings

Following ratings at 60 Hz shall be as indicated on contract drawings and documents:

Nominal voltage (kV)
Rated maximum voltage (kV
Rated continuous current (A)
Three-second short-time current-carrying capacity (kA)
BIL (kV)

2.9.5.2 Enclosures

Switchgear enclosures shall be of freestanding, self-supporting construction provided with separate incoming and outgoing compartments configured for bottom cable entry. Enclosures shall be of deadfront construction, provided with a hinged door for access to each compartment, and conform to the requirements of IEEE C57.12.28 and IEEE C37.20.3, Category A.

2.9.6 Cable Terminating Cabinets

Cable terminating cabinets shall be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Cabinets shall be provided with loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs or dead-break junctions and elbow-type separable dead-break connectors, cable parking stands, and grounding lugs as indicated on contract drawings and documents. The cable terminating equipments shall conform to IEEE 386.

Following ratings at 60 Hz shall be as indicated on contract drawings and documents.

Nominal voltage (kV)
Rated maximum voltage (kV
Rated continuous current (A)
Three-second short-time current-carrying capacity (kA)
BIL (kV)

2.10 METERING AND PROTECTIVE DEVICES

2.10.1 Circuit Breakers, Low-Voltage

2.10.1.1 Low-Voltage Power Circuit Breakers

a. Construction. Low-voltage power circuit breakers shall conform to IEEE C37.13 and IEEE C37.16, and shall be three-pole, single-throw, stored energy, manually or electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of primary disconnections when the circuit breaker is closed. Control voltage shall be as indicated. The circuit breaker enclosure shall be suitable for its intended location.

b. Ratings. Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with IEEE C37.16. Tripping features shall be as follows:

   (1) Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

   (2) Adjustable long-time delay.

   (3) Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

   (4) Adjustable short-time delay.

   (5) Short-time I2t switch.

   (6) Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

   (7) Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as shown.

   (8) Fixed or Adjustable ground-fault delay.

   (9) Ground-fault I2t switch.

(10) Overload and short-circuit and ground-fault trip indicators shall be provided.

2.10.1.2 Molded-Case Circuit Breakers

UL 489 and UL 489.

2.10.2 Fuses, Medium-Voltage, Including Current-Limiting

2.10.2.1 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.10.2.2 Ratings

Expulsion-type or Current-limiting power fuses shall have ratings in accordance with IEEE C37.46 and as indicated on contract drawings and documents.

Nominal voltage (kV)
Rated maximum voltage (kV
Rated continuous current (A)
Maximum symmetrical interrupting capacity (kA)
BIL (kV)

2.10.2.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to IEEE C37.46.

2.10.2.4 C-Rated, Current-Limiting Power Fuses

C-rated, current-limiting power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.10.3 Fuses, Low-Voltage, Including Current-Limiting

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as specified. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics required for effective power system coordination.

2.10.3.1 Cartridge Fuses

Cartridge fuses, current-limiting type, Class G, J, K, L, RK1, RK5, RK9, T, or CC shall have tested interrupting capacity not less than 100,000 or 200,000 amperes as indicated on contract drawings and documents. Fuse holders shall be the type that will reject Class H fuses.

a. Class G, J, L, or CC fuses shall conform to UL 198M.

b. Class K fuses shall conform to UL 198M.

c. Class R fuses shall conform to UL 198M.

d. Class T fuses shall conform to UL 198M.

2.10.3.2 Transformer Circuit Fuses

Transformer circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.10.4 Instrument Transformers

2.10.4.1 General

Instrument transformers shall comply with NEMA/ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on drawings.

2.10.4.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be as indicated in the table below. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accident open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

RATIO	RF at 30 degrees C
200/5	4.0
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5

RATIO	RF at 30 degrees C
1500/5	1.5
2000/5	1.5
3000/5	1.33

2.10.4.3 Current Transformers for Power Transformers

Single-ratio or Multi-ratio bushing type current transformers shall be provided internally around power transformer bushings as shown. Single-ratio units shall have a minimum relaying accuracy class of 0.6B-0.5 or 0.3B-0.5. Multi-ratio units shall have a minimum relaying accuracy voltage class of 0.3 for either a C or T classification.

2.10.4.4 Current Transformers for Metal-Enclosed Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of 0.3 B.0.5. Single-ratio units, used only for relaying, shall have a relaying accuracy class rating of 0.3 for either a C or T classification.

2.10.4.5 Current Transformers for Kwh and Demand Metering (Low-Voltage)

Current transformers shall conform to IEEE C57.13. Provide current transformers with a metering accuracy Class as indicated in the table below,with a minimum RF as indicated in the table below at 30 degrees C (86 degrees F), with 600-volt insulation, and 10 kV BIL. Provide butyl-molded, window-type current transformers mounted on the transformer low-voltage bushings. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters.

RATIO	RF at 30 degrees C
200/5	4.0
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5
1500/5	1.5
2000/5	1.5
3000/5	1.33

Primary Amp Rating (of CT)	Accuracy Class
200	0.3 thru B-0.1
300-400	0.3 thru B-0.2
600-1200	0.3 thru B-0.5
1500	0.3 thru B-0.9
2000-3000	0.3 thru B-1.8

2.10.4.6 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy class rating of 0.3 at all burdens W, X, Y, and Z. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.10.5 Watthour Meters

Watthour meters shall conform to NEMA/ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the drawout switchboard type, socket mounted outdoor or indoor type having a 15 minute, cumulative form, demand register meeting NEMA C12.4 and provided with not less than 2-1/2 stators. Watthour demand meters shall have factory-installed electronic pulse initiators. Pulse initiators shall be solid-state devices incorporating light-emitting diodes, phototransistors, and power transistors, except that mercury-wetted output contacts are acceptable. Initiators shall be totally contained within watthour demand meter enclosures, shall be capable of operating up to speeds of 500 pulses per minute with no false pulses, and shall require no field adjustments. Initiators shall be calibrated for a pulse rate output of 1 pulse per 1/4 disc revolution of the associated meter and shall be compatible with the indicated equipment.

2.10.6 Protective Relaying

2.10.6.1 General

Microprocessor-based protective relays shall be provided as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.10.6.2 Construction

Relays shall be dustproof and moisture resistant. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.10.6.3 Ratings

Relays shall be the manufacturer's standard items of equipment with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.11 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1, and IEEE C62.11 and shall be provided where indicated. Arresters shall be station, intermediate, or distribution class, and rated as indicated on contract drawings and documents. Arresters for use at elevations in excess of 1.8 km (6000 feet) above mean sea level shall be specifically rated for that purpose. Arresters shall be equipped with mounting brackets suitable for the indicated installations. Arresters shall be of the metal-oxide varistor type.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Ground rods shall be copper-clad steel conforming to UL 467 or zinc-coated steel conforming to IEEE C135.30 not less than 19 mm (3/4 inch) in diameter by 3.1 m (10 feet) in length. Sectional type rods may be used.

2.12.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.13 CONCRETE AND REINFORCEMENT

Concrete work shall have minimum 20 MPa (3000 psi) compressive strength and conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE. Concrete reinforcing shall be as specified in Section 03 20 00.00 10 CONCRETE REINFORCING.

2.14 PADLOCKS

Padlocks shall comply with Section 08 71 00 DOOR HARDWARE.

2.15 CABLE FIREPROOFING SYSTEMS

Cable fireproofing systems shall be listed in FM APP GUIDE tape approved for grouped electrical conductors and shall be suitable for application on the type of medium-voltage cables provided. After being fully cured, materials shall be suitable for use where exposed to oil, water, gases, salt water, sewage, and fungus and shall not damage cable jackets or insulation. Asbestos materials are not acceptable.

2.15.1 Fireproofing Tape

Fireproofing tape shall be at least 50 mm (2 inches) wide and shall be a flexible, conformable, polymeric, elastomer tape designed specifically for fireproofing cables.

2.15.2 Plastic Tape

Preapplication plastic tape shall be pressure sensitive, 0.254 mm (10 mil) thick, conforming to UL 510.

2.16 LIQUID DIELECTRICS

Liquid dielectrics for transformers, capacitors, reclosers, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral-oil or less-flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than 2 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D923 and have tests performed in accordance with ASTM D4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 2 ppm shall be replaced.

2.17 FACTORY TESTS

Submit certified factory test reports when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests. The manufacturer's pass-fail criteria for tests specified in paragraph FIELD TESTING shall be included. Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 10 days before the equipment is ready for testing. The Contracting Officer reserves the right to witness the tests.

a. Transformers: Manufacturer's standard routine, design, and other tests in accordance with IEEE C57.12.00.

b. Transformers rated 200 kVA and above: Reduced full-wave, chopped-wave, and full-wave impulse test on each line and neutral terminal, in accordance with IEEE C57.98.

c. High-Voltage Air Switches: Manufacturer's standard tests in accordance with IEEE C37.34 and IEEE C37.41.

d. Protective Relays: Seismic tests in accordance with IEC 60255-21-3. Surge withstand tests in accordance with IEEE C37.90.1.

e. Relaying Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

f. Instrument Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

g. Factory Preformed Terminations: Wet withstand voltage tests in accordance with IEEE 48 for the next higher BIL level.

h. Outdoor Switchgear: Manufacturer's standard tests in accordance with IEEE C37.20.1, IEEE C37.20.2, and IEEE C37.20.3.

i. Electrical Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.

2.18 FENCING

Fencing shall conform to the requirements of Section 32 31 13 CHAIN LINK FENCES AND GATES.

2.19 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.19.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at the nearest upstream device in the existing source system and extend through the downstream devices at the load end.

2.19.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the commercial power company for fault current availability at the site.

2.19.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.19.4 Fault Current Analysis

2.19.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, and IEEE 399.

2.19.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.19.5 Coordination Study

Submit the study with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government will not be responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and any relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.19.6 Study Report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristics curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided. Software model files used for study, calculation, and analysis shall be provided to the Contracting Officer Representative (COR) or Base Civil Engineer (for Air Force projects). For Air Force projects, the analysis shall be performed using Easy Power analysis software. Contractor shall not be required to obtain and provide software licenses to the Government unless it is explicitly requested in contract drawings or specifications.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION REQUIREMENTS

As a minimum, submit installation procedures for transformers, substations, switchgear, and splices. Procedures shall include cable pulling plans, diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment. Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed aerially shall conform to the requirements of Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 31 00 00 EARTHWORK. Concrete work shall have minimum 20 MPa (3000 psi) compressive strength and conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable.

3.2.2 Disposal of Liquid Dielectrics

PCB-contaminated dielectrics must be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. Furnish certification of proper disposal. Contaminated dielectrics shall not be diluted to lower the contamination level.

3.3 CABLE AND BUSWAY INSTALLATION

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, etc. Contractor shall then prepare a checklist of significant requirements and perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturer's instructions in accordance with SUBMITTALS.

3.3.1 Cable Installation Plan and Procedure

Cable shall be installed strictly in accordance with the cable manufacturer's recommendations. Each circuit shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

3.3.1.1 Cable Inspection

The cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable in accordance with the cable manufacturer's recommendations.

3.3.1.2 Duct Cleaning

Duct shall be cleaned with an assembly that consists of a flexible mandrel (manufacturers standard product in lengths recommended for the specific size and type of duct) that is 6.4 mm (1/4 inch) less than inside diameter of duct, 2 wire brushes, and a rag. The cleaning assembly shall be pulled through conduit a minimum of 2 times or until less than a volume of 131 cubic centimeters (8 cubic inches) of debris is expelled from the duct.

3.3.1.3 Duct Lubrication

The cable lubricant shall be compatible with the cable jacket for cable that is being installed. Application of lubricant shall be in accordance with lubricant manufacturer's recommendations.

3.3.1.4 Cable Installation

Provide a cable feeding truck and a cable pulling winch as required. Provide a pulling grip or pulling eye in accordance with cable manufacturer's recommendations. The pulling grip or pulling eye apparatus shall be attached to polypropylene or manila rope followed by lubricant front end packs and then by power cables. A dynamometer shall be used to monitor pulling tension. Pulling tension shall not exceed cable manufacturer's recommendations. Do not allow cables to cross over while cables are being fed into duct. For cable installation in cold weather, cables shall be kept at 10 degrees C (50 degrees F) temperature for at least 24 hours before installation. Submit one hard copy and one digital copy (.pdf - text searchable) of the information described below. Hard copy shall be in 215.9 by 279.4 mm (8-1/2 by 11 inch) binder having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

3.3.1.5 Cable Installation Plan

Submit a cable installation plan for all cable pulls in accordance with the detail drawings portion of paragraph SUBMITTALS. Cable installation plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall thrust pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.3.2 Duct Line

Cables shall be installed in duct lines where indicated. Cable splices in low-voltage cables shall be made in manholes and handholes only, except as otherwise noted. Cable joints in medium-voltage cables shall be made in manholes or approved pullboxes only. Neutral and grounding conductors shall be installed in the same duct with their associated phase conductors.

3.3.3 Direct-Burial

Cables shall be buried directly in the earth as indicated. Minimum cover from the top of a cable to finished grade shall be as shown but not less than the depth of the frost line. Maximum cover from the top of a cable to finished grade shall be the depth of the frost line, 1220 mm (48 inches).

3.3.3.1 Trenching

Trenches for direct-burial cables shall be excavated to depths required to provide the minimum necessary cable cover. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm (3 inch) layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil.

3.3.3.2 Cable Burial

Cables shall be unreeled along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position will not be permitted, except as required to pull cables through conduits under paving or railroad tracks. Where cables cross, a separation of at least 75 mm (3 inches) shall be provided, unless each cable circuit is protected by a nonmetallic conduit sleeve at the crossing. Where single-conductor cable is installed, all 3 phases and the neutral shall be installed in the same sleeve. Bend radius of any cable shall be not less than 12 times the diameter of the cable. In no case shall cables be left under longitudinal tension. The first 150 mm (6 inch) layer of backfill shall be of sand. Machine compaction shall not be used within 150 mm (6 inches) of the cable.

3.3.3.3 Other Requirements

Where direct-burial cables cross under roads or other paving exceeding 1.5 m (5 feet) in width, such cables shall be installed in concrete-encased ducts. Where direct-burial cables cross under railroad tracks, such cables shall be installed in reinforced concrete-encased ducts. Ducts shall extend at least 300 mm (1 foot) beyond each edge of any paving and at least 1.5 m (5 feet) beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables shall be centered in duct entrances, and a waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, the paving and subbase shall be restored to their original condition.

3.3.3.4 Cable Joints or Splices

Cable joints or splices for Medium-Voltage Cable Joints or Low-Voltage Cable Splices in direct-burial cables are neither permitted in runs of 305 m (1000 feet) or less, nor at intervals of less than 305 m (1000 feet) in longer runs, except as required for taps. Locations of cable joints or splices in shorter intervals, where required to avoid obstructions or damage to cables, shall be approved. Cable joints or splices in direct burial installations shall be installed in above-ground junction boxes or in cast metal splice boxes suitable for direct burial use. Cable joints or splices in duct banks shall be made only in manholes, handholes, or pullboxes.

3.3.3.5 Cable Markers

Markers shall be located near the ends of cable runs, at each cable joint or splice, at approximately every 150 m (500 feet) along cable runs, and at changes in direction of cable runs. In addition to markers, a 0.127 mm (5 mil), brightly colored plastic tape not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers, or other approved dig-in warning indication, shall be placed approximately 300 mm (12 inches) below finished grade levels of trenches.

3.3.4 Insect and Rodent Damage

Animal guards shall be installed as shown. Buried fiberglass pads shall be installed as shown.

3.3.5 Electric Manholes

Cables shall be routed around the interior walls and securely supported from walls on cables racks. Cable routing shall minimize cable crossover, provide access space for maintenance and installation of additional cables, and maintain cable separation in accordance with IEEE C2.

3.3.6 Busway Installation

Busways penetrating walls shall have wall flanges installed on both surfaces of walls. Wall openings shall be approximately 6.4 mm (1/4 inch) larger than the busway on each of the 4 busway sides, and openings shall be sealed with a suitable compound. Fire barriers shall be provided when penetrating fire rated walls. Fire barriers shall have a rating equal to the fire wall rating. A weather barrier shall be used when a busway penetrates an exterior wall. Busways shall be supported at intervals not exceeding 3 m (10 feet) and shall be braced to prevent lateral movement.

3.4 CABLE JOINTS

Medium-voltage cable joints shall be made by qualified cable splicers only. Qualifications of cable splicers shall be submitted with a certification that contains the names of people recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and terminations has been adequately trained in the proper techniques and have had at least three recent years of experience in splicing and terminating the same or similar types of cables approved for installation. In addition, any person recommended by the Contractor may be required to perform a practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, provide short sections of the approved types of cables along with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types.. Shields shall be applied as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of preformed joints. Shields shall be grounded at each joint or in accordance with manufacturer's recommended practice. Cable joints shall provide insulation and jacket equivalent to that of the associated cable. Armored cable joints shall be enclosed in compound-filled, cast-iron or alloy, splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

3.5 FIREPROOFING

Each medium-voltage cable and conductor in manholes shall be fire-proofed for their entire length within the manhole. Where cables and conductors have been lubricated to enhance pulling into ducts, the lubricant shall be removed from cables and conductors exposed in the manhole before fireproofing. Fire-stops shall be installed in each conduit entering or leaving a manhole.

3.5.1 Tape Method

Before application of fireproofing tape, plastic tape wrapping shall be applied over exposed metallic items such as the cable ground wire, metallic outer covering, or armor to minimize the possibility of corrosion from the fireproofing materials and moisture. Before applying fireproofing tape, irregularities of cables, such as at cable joints, shall be evened out with insulation putty. A flexible conformable polymeric elastomer fireproof tape shall be wrapped tightly around each cable spirally in 1/2 lapped wrapping or in 2 butt-jointed wrappings with the second wrapping covering the joints of the first.

3.6 DUCT LINES

3.6.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 100 mm per 30 m (4 inches per 100 feet). Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) for ducts of less than 80 mm (3 inch) diameter, and 900 mm (36 inches) for ducts 80 mm (3 inches) or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m (25 feet) shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes or handholes. Spare ducts shall be plugged at both ends to prevent entry of water, other liquids, or solid material.

3.6.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Concrete Encasement

Ducts requiring concrete encasements shall comply with NFPA 70, except that electrical duct bank configurations for ducts 150 mm (6 inches) in diameter shall be determined by calculation and as shown on the drawings. The separation between adjacent electric power and communication ducts shall conform to IEEE C2. Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. Submit proposed bonding method for approval in accordance with the detail drawing portion of paragraph SUBMITTALS. At any point, except railroad and airfield crossings, tops of concrete encasements shall be not less than the cover requirements listed in NFPA 70. At railroad and airfield crossings, duct lines shall be encased with concrete and reinforced as indicated to withstand specified surface loadings. Tops of concrete encasements shall be not less than 1.5 m (5 feet) below tops of rails or airfield paving unless otherwise indicated. Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m (50 feet) in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m (4 feet) on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 150 mm (6 inches) vertically.

3.6.4 Nonencased Direct-Burial

Top of duct lines shall be below the frost line depth of 1200 mm (48 inches), and shall be installed with a minimum of 75 mm (3 inches) of earth around each duct, except that between adjacent electric power and communication ducts, 300 mm (12 inches) of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm (3 inch) layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts. Joints in adjacent tiers of duct shall be vertically staggered at least 150 mm (6 inches). The first 150 mm (6 inch) layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm (3 to 6 inch) layers. Duct banks may be held in alignment with earth. However, high-tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling.

3.6.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved.

3.6.5.1 Bituminized-Fiber Ducts

Bituminized-fiber ducts shall be used to interface with existing bituminized-fiber duct as shown. To ensure a watertight joint, tapered ends or joints of the same material as the ducts shall be swabbed with bituminous or joint-sealing compound before couplings are applied. Plastic or nonmetallic couplings shall be tightly driven onto unswabbed ducts. Due to the brittleness of plastic couplings at low temperatures, such couplings shall not be installed when temperatures are below minus 18 degrees C (0 degrees F). Couplings shall be warmed in hot water or by another approved method when installed at temperatures below 0 degrees C (32 degrees F).

3.6.5.2 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick 1/4-turn twist to set the joint tightly.

3.6.6 Duct Line Markers

Duct line markers shall be provided as indicated and at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In addition to markers, a 0.127 mm (5 mil) brightly colored plastic tape, not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers with a continuous metallic backing and a corrosion-resistant 0.0254 mm (1 mil) metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm (12 inches) below finished grade levels of such lines.

3.7 MANHOLES, HANDHOLES, AND PULLBOXES

3.7.1 General

Manholes shall be constructed approximately where shown. The exact location of each manhole shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. The location of each manhole shall be approved by the Contracting Officer before construction of the manhole is started. Manholes shall be the type noted on the drawings and shall be constructed in accordance with the applicable details as indicated. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. The Contractor may, as an option, utilize monolithically constructed precast-concrete manholes having the required strength and inside dimensions as required by the drawings or specifications. In paved areas, frames and covers for manhole and handhole entrances in vehicular traffic areas shall be flush with the finished surface of the paving. In unpaved areas, the top of manhole covers shall be approximately 15 mm (1/2 inch) above the finished grade. Where existing grades that are higher than finished grades are encountered, concrete assemblies designed for the purpose shall be installed to elevate temporarily the manhole cover to existing grade level. All duct lines entering manholes must be installed on compact soil or otherwise supported when entering a manhole to prevent shear stress on the duct at the point of entrance to the manhole. Duct lines entering cast-in-place concrete manholes shall be cast in-place with the manhole. Duct lines entering precast concrete manholes through a precast knockout penetration shall be grouted tight with a portland cement mortar. PVC duct lines entering precast manholes through a PVC endbell shall be solvent welded to the endbell. A cast metal grille-type sump frame and cover shall be installed over the manhole sump. A cable-pulling iron shall be installed in the wall opposite each duct line entrance. Spare ducts shall be plugged at both ends to prevent entry of water, other liquids, or solid material.

3.7.2 Electric Manholes

Cables shall be securely supported from walls by hot-dip galvanized cable racks with a plastic coating over the galvanizing and equipped with adjustable hooks and insulators. The number of cable racks indicated shall be installed in each manhole and not less than 2 spare hooks shall be installed on each cable rack. Insulators shall be made of high-glazed porcelain. Insulators will not be required on spare hooks.

3.7.3 Communications Manholes

The number of hot-dip galvanized cable racks with a plastic coating over the galvanizing indicated shall be installed in each telephone manhole. Each cable rack shall be provided with 2 cable hooks. Cables for the telephone and communication systems will be installed by others.

3.7.4 Handholes

Handholes shall be located approximately as shown. Handholes shall be of the type noted on the drawings and shall be constructed in accordance with the details shown. Handholes shall not be used for medium voltage distribution lines.

3.7.5 Pullboxes

Pullbox tops shall be flush with sidewalks or curbs or placed 15 mm (1/2 inch) above surrounding grades when remote from curbed roadways or sidewalks. Covers shall be marked "Low-Voltage" and provided with 2 lifting eyes and 2 hold-down bolts. Each box shall have a suitable opening for a ground rod. Conduit, cable, ground rod entrances, and unused openings shall be sealed with mortar.

3.7.6 Ground Rods

A ground rod shall be installed at the manholes, handholes and pullboxes. Ground rods shall be driven into the earth before the manhole floor is poured so that approximately 100 mm (4 inches) of the ground rod will extend above the manhole floor. When precast concrete manholes are used, the top of the ground rod may be below the manhole floor and a No. 1/0 AWG ground conductor brought into the manhole through a watertight sleeve in the manhole wall.

3.8 PAD-MOUNTED EQUIPMENT INSTALLATION

Pad-mounted equipment, shall be installed on concrete pads in accordance with the manufacturer's published, standard installation drawings and procedures, except that they shall be modified to meet the requirements of this document. Units shall be installed so that they do not damage equipment or scratch painted or coated surfaces. After installation, surfaces shall be inspected and scratches touched up with a paint or coating provided by the manufacturer especially for this purpose.

3.8.1 Concrete Pads

3.8.1.1 Construction

Concrete pads for pad-mounted electrical equipment may be either pre-fabricated or shall be poured-in-place. Pads shall be constructed as indicated, except that exact pad dimensions and mounting details are equipment specific and are the responsibility of the Contractor. Tops of concrete pads shall be level and shall project 100 mm (4 inches) above finished floor, paving, or grade and sloped to drain away from equipment. Edges of concrete pads shall have 19 mm (3/4 inch) chamfer. Conduits for primary, secondary, and grounding conductors shall be set in place prior to placement of concrete pads. Where grounding electrode conductors are installed through concrete pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. To facilitate cable installation and termination, the concrete pad shall be provided with a rectangular hole below the primary and secondary compartments, sized in accordance with the manufacturer's recommended dimensions. Upon completion of equipment installation the rectangular hole shall be filled with masonry grout.

3.8.1.2 Concrete and Reinforcement

Concrete work shall have minimum 20 MPa (3000 psi) compressive strength and conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE. Concrete pad reinforcement shall be in accordance with Section 03 20 00.00 10 CONCRETE REINFORCING.

3.8.1.3 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.8.2 Padlocks

Padlocks shall be provided for pad-mounted equipment and for each fence gate. Padlocks shall be keyed alike as directed by the Contracting Officer.

3.8.3 Fencing

Fencing shall conform to the requirement of and be installed in accordance with Section 32 31 13 CHAIN LINK FENCES AND GATES. Fences shall provide working clearances for operation and maintenance in accordance with IEEE C2. The entire space between fences and concrete pads shall be excavated to a minimum depth of 100 mm (4 inches) below finished gradelines, shall be graded to reasonably level surfaces, and filled with well-compacted clean coarse gravel or crushed stone of 13 to 40 mm (1/2 to 1-1/2 inches) graded size up to finished gradelines.

3.9 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in conduit to cable terminations. Conduits shall be secured to the poles by 2-hole galvanized steel pipe straps spaced not more than 3 m (10 feet) apart and with 1 strap not more than 300 mm (12 inches) from any bend or termination. Cable guards shall be secured to poles in accordance with the manufacturer's published procedures. Conduits shall be equipped with bushings to protect cables and minimize water entry. Capnut potheads shall be used to terminate medium-voltage multiple-conductor cable. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the conduit or guard. Pole installation shall be in accordance with Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.10 CONNECTIONS TO BUILDINGS

Cables shall be extended into the various buildings as indicated, and shall be connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 1.5 m (5 feet) outside of a building and 1200 mm (4 feet) below finished grade as specified and provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.11 GROUNDING

A ground mat or ring consisting of the indicated configuration of bare copper conductors and driven ground rods shall be installed around pad-mounted equipment as shown. Equipment frames of metal-enclosed equipment, and other noncurrent-carrying metal parts, such as cable shields, cable sheaths and armor, and metallic conduit shall be grounded. At least 2 connections shall be provided from a transformer, a switchgear ground bus, and a unit substation to the ground mat. Metallic frames and covers of handholes and pull boxes shall be grounded by use of a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.11.1 Grounding Electrodes

Grounding electrodes shall be installed as shown on the drawings and as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be driven into the earth until the tops of the rods are approximately 300 mm (1 foot) below finished grade.

b. Ground mat - A ground mat shall be installed as shown consisting of bare copper conductors installed 600 mm (24 inches), plus or minus 75 mm (3 inches), below the finished top of soil grade. Mat conductors shall be bonded to all rod electrodes, electrolytic electrodes, and to all other intersecting mat conductors. Mat conductors shall be sized as shown on the drawings.

c. Ground ring - A ground ring shall be installed as shown consisting of bare copper conductors installed not less than 750 mm (30 inches) below finished top of soil grade. Ground ring conductors shall be sized as shownor No. 2 AWG, minimum.

d. Additional electrodes - When the required ground resistance is not met, additional electrodes shall be provided interconnected with grounding conductors to achieve the specified ground resistance. The additional electrodes will be up to three, 3 m (10 feet) rods spaced a minimum of 3 m (10 feet) apart or a single extension-type rod, 19.1 mm (3/4 inch) diameter, up to 9.1 m (30 feet) long, driven perpendicular to grade coupled and driven with the first rod. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.11.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors, in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.11.3 Grounding and Bonding Conductors

Grounding and bonding conductors include conductors used to bond transformer enclosures and equipment frames to the grounding electrode system. Grounding and bonding conductors shall be sized as shown, and located to provide maximum physical protection. Bends greater than 45 degrees in ground conductors are not permitted. Routing of ground conductors through concrete shall be avoided. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor, and the opening shall be sealed with a suitable compound after installation.

3.11.4 Surge Arrester Grounding

Surge arresters and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with a bare copper conductor, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends.

3.11.5 Manhole, Handhole, or Concrete Pullbox Grounding

Ground rods installed in manholes, handholes, or concrete pullboxes shall be connected to cable racks, cable-pulling irons, the cable shielding, metallic sheath, and armor at each cable joint or splice by means of a No. 4 AWG braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 50 mm (2 inches) above and 150 mm (6 inches) below concrete penetrations. Grounding electrode conductors shall be neatly and firmly attached to manhole or handhole walls and the amount of exposed bare wire shall be held to a minimum.

3.11.6 Metal Splice Case Grounding

Metal splice cases for medium-voltage direct-burial cable shall be grounded by connection to a driven ground rod located within 600 mm (2 feet) of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

3.11.7 Riser Pole Grounding

A single continuous vertical grounding electrode conductor shall be installed on each riser pole and connected directly to the grounding electrodes indicated on the drawings or required by these specifications. All equipment, neutrals, surge arresters, and items required to be grounded shall be connected directly to this vertical conductor. The grounding electrode conductor shall be sized as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm (2 feet).

3.12 FIELD TESTING

Submit a proposed field test plan, 10 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

3.12.1 General

Field testing shall be performed in the presence of the Contracting Officer. Notify the Contracting Officer 10 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field test reports shall be signed and dated by the Contractor.

3.12.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.12.3 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 25 ohms.

b. Multiple rod electrodes - 25 ohms.

c. Ground mat - 25 ohms.

d. Ground ring - 25 ohms.

3.12.4 Ground-Mat Connection Inspection

All below-grade ground-mat connections will be visually inspected by the Contracting Officer before backfilling. Notify the Contracting Officer 72 hours before the site is ready for inspection.

3.12.5 Medium-Voltage Cable Test

After installation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds or metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be for the particular type of cable installed, except that 28 kV and 35 kV insulation test voltages shall be in accordance with either AEIC C8 or AEIC CS8 as applicable, and shall not exceed the recommendations of IEEE 404 for cable joints and IEEE 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.12.6 Low-Voltage Cable Test

Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energizing. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

R in megohms = (rated voltage in kV + 1) x 304.8/(length of cable in meters)(R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Each cable failing this test shall be repaired or replaced. The repaired cable shall be retested until failures have been eliminated.

3.12.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on all liquid-filled transformers. Pass-fail criteria shall be in accordance with transformer manufacturer's specifications.

a. Insulation resistance test phase-to-ground.

b. Turns ratio test.

c. Correct phase sequence.

d. Correct operation of tap changer.

3.12.8 Dry-Type Transformer Tests

The following field tests shall be performed on all dry-type transformers. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

a. Insulation resistance test phase-to-ground.

b. Turns ratio test.

3.12.9 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers. Pass-fail criteria shall be in accordance with the circuit breaker manufacturer's specifications.

a. Insulation resistance test phase-to-phase.

b. Insulation resistance test phase-to-ground.

c. Closed breaker contact resistance test.

d. Power factor test.

e. High-potential test.

f. Manual and electrical operation of the breaker.

3.12.10 Power Circuit Breaker Tests

Power circuit breakers shall be tested in accordance with NEMA C37.50.

3.12.11 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.12.12 Pre-Energizing Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energizing. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

a. Secondary unit substation
b. Pad-mounted transformers
c. Panelboards
d. Switchboards
e. Metal-enclosed switchgear
f. Busways
g. Switches

3.12.13 Operating Tests

After the installation is completed, and at such times as the Contracting

Officer may direct, conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the requirements herein. Submit 6 copies of the tests report in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of three rings, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. The operating test report shall include the following:

a. A list of equipment used, with calibration certifications.
b. A copy of measurements taken.
c. The dates of testing.
d. The equipment and values to be verified.
e. The condition specified for the test.
f. The test results, signed and dated.
g. A description of adjustments made.

3.13 MANUFACTURER'S FIELD SERVICE

3.13.1 Onsite Training

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instructions shall demonstrate all routine maintenance operations.

a. The course instruction shall cover pertinent points involved in operating, starting, stopping, and servicing the equipment, as well as all major elements of the operation and maintenance manuals. Submit one hard copy and one digital copy (.pdf - text searchable) of operation and maintenance manuals, within 7 calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked.

b. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included.

c. Hard copy documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

3.13.2 Installation Engineer

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. A resume shall be provided showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. After delivery of the equipment, furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.14 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --

SECTION 33 71 01

OVERHEAD TRANSMISSION AND DISTRIBUTION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.14	(1979) Staples with Rolled or Slash Points for Overhead Line Construction

ASME INTERNATIONAL (ASME)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A475	(2003; R 2009e1) Standard Specification for Zinc-Coated Steel Wire Strand
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A575	(1996; R 2007) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A576	(1990b; R 2012) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B2	(2008) Standard Specification for

	Medium-Hard-Drawn Copper Wire
ASTM B232/B232M	(2011) Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)
ASTM B3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D117	(2010) Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D3487	(2009) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM D709	(2013) Laminated Thermosetting Materials
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D92	(2012) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2011) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 18	(2002; INT 1 2005) Standard for Shunt Power Capacitors
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE C135.1	(1999) Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction
IEEE C135.2	(1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for

	Overhead Line Construction
IEEE C135.22	(1988) Standard for Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C37.32	(2002) Standard for High-Voltage Switches, Bus Supports, and Accessories - Schedules of Preferred Ratings, Construction Guidelines and Specifications
IEEE C37.41	(2008; Errata 2009) Standard Design Tests for High-Voltage (>1000 V) Fuses, Fuse and Disconnecting Cutouts, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories Used with These Devices
IEEE C37.42	(2009) Standard Specifications for High-Voltage (> 1000 V) Expulsion-Type Distribution-Class Fuses, Fuse and Disconnecting Cutouts, Fuse Disconnecting Switches, and Fuse Links, and Accessories Used with These Devices
IEEE C37.63	(2005) Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.20	(2011) Standard for Overhead Type Distribution Transformers, 500 KVA and Smaller: High Voltage 34 500 Volts and Below: Low Voltage, 7970/13,800 Y Volts and Below
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.90	(2010) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2008; INT 2009) Standard Requirements for Instrument Transformers
IEEE C57.15	(2009) Standard Requirements, Terminology,

	and Test Code for Step-Voltage Regulators
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62271-111	(2005) High Voltage Switchgear And Controlgear - Part 111: Overhead, Pad-Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters For Alternating Current Systems Up To 38 kV; Ed 1.0

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.7	(2005) Requirements for Watthour Meter Sockets
ANSI C29.2	(1992; R 1999) American National Standard for Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type
ANSI C29.3	(1986; R 2002) American National Standard for Wet Process Porcelain Insulators - Spool Type
ANSI C29.4	(1989; R 2002) Standard for Wet-Process Porcelain Insulators - Strain Type
ANSI C29.5	(1984; R 2002) Wet-Process Porcelain Insulators (Low and Medium Voltage Pin Type)
ANSI C29.7	(1996; 2007) American National Standard for Wet Process Porcelain Insulators - High-Voltage Line Post Type
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA C135.4	(1987) Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical

	Energy--S95-658
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 202-1	(2004) List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-90/027F	(1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
EPA 712-C-98-075	(1996) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Pole top switch

Recloser; G

Sectionalizer; G

Cutouts; G

Transformer; G

Metering equipment; G

Meters; G

Surge arresters

Steel Poles

Anchors

SD-06 Test Reports

Field Quality Control

Ground resistance test reports

Submit report of the acceptance test results as specified by paragraph entitled "Field Quality Control"

SD-09 Manufacturer's Field Reports

Overhead-type distribution transformer routine and other tests

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals, Data Package 5

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

Transformer test schedule

1.5 QUALITY ASSURANCE

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 and IEEE C2 unless more stringent requirements are specified or indicated.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5.3 Ground Resistance Test Reports

Submit the measured ground resistance of grounding system. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

1.6 MAINTENANCE

1.6.1 Additions to Operations and Maintenance Data

In addition to requirements of Data Package 5, include the following in the operation and maintenance manuals provided:

a. Assembly and installation drawings

b. Prices for spare parts and supply list

c. Date of purchase

1.7 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.8 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Consider materials specified herein or shown on contract drawings which are identical to materials listed in RUS 202-1 as conforming to requirements. Equipment and component items, not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The described test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.2 POLES

Poles shall be of lengths and strengths as indicated on contract drawings and documents.

2.2.1 Steel Poles

Steel poles shall be designed to withstand the loads specified in IEEE C2 or KS F 4304 multiplied by the appropriate overload capacity factors, shall be hot-dip galvanized in accordance with ASTM A123/A123M and shall not be painted. Poles shall have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Calculations shall be submitted in accordance with the design data portion of paragraph entitled "SUBMITTALS." Provide certification, from the manufacturer, that the technical requirements of this specification shall be met. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1270 mm (3 to 4 feet) above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Attachment requirements shall be provided as indicated, including grounding provisions. Climbing facilities are not required. Bases shall be of the anchor-bolt-mounted type.

2.2.2 Concrete Poles

Concrete poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors. Poles shall be reinforced or prestressed, either cast or spun. Spun poles shall be manufactured by a centrifugal spinning process with concrete pumped into a polished round tapered metal mold. Concrete for spun poles shall have a compressive strength of at least 34.5 MPa (5000 psi) at 28 days; steel wire shall have an ultimate tensile strength of at least 827 MPa; (120,000 psi); and reinforcing bars shall have an ultimate tensile strength of at least 276 MPa (40,000 psi). After the high speed spinning action is completed, a spun pole shall be cured by a suitable wet steam process. Spun poles shall have a water absorption of not greater than three percent to eliminate cracking and to prevent erosion. Concrete poles shall have hollow shafts. Poles shall have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost. Poles shall not be installed for at least 15 days after manufacture. Fittings and brackets that conform to the concrete pole design shall be provided. Poles shall conform to strength calculations performed by a registered professional engineer and submitted in accordance with design data portion of paragraph entitled "SUBMITTALS." Provide certification, from the manufacturer, that the technical requirements of this specification shall be met.

2.3 CROSSARMS AND BRACKETS

2.3.1 Steel Crossarms

Crossarms shall be hot dip galvanized steel and 2.4 m (8 feet) in length, except that 3.1 m (10 foot) crossarms shall be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 2.5 mm per 304.8 mm (1/10 inch per foot) of length. Bend or twist shall be in one direction only.

2.3.2 Crossarm Braces

Provide flat steel or steel angle as indicated. Provide braces with 965 mm span with 2440 mm crossarms and 1520 mm span with 3050 mm crossarms (38 inch span for 8 foot crossarms and 60 inch span for 10 foot crossarms).

2.3.3 Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators shall be as indicated on contract drawings and documents. Brackets shall be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of the pole. Horizontal offset brackets shall have a 5-degree uplift angle. Pole top brackets shall conform to IEEE C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than (2800 pound) cantilever strength.

2.4 HARDWARE

Hardware shall be hot-dip galvanized in accordance with ASTM A153/A153M or KS D 8308 and ASTM A123/A123M.

Zinc-coated hardware shall comply with IEEE C135.1, IEEE C135.2, NEMA C135.4, ANSI C135.14 IEEE C135.22. Steel hardware shall comply with ASTM A575 and ASTM A576 or KS D 3501 and KS D 3515. Pole-line hardware shall be hot-dip galvanized steel, except anchor rods of the copper-molten welded-to-steel type with nonferrous corrosion-resistant fittings shall be used. Washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 57.2 mm square (2-1/4 inches square) and 4.8 mm (3/16 inch) thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises shall be used wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

2.5 INSULATORS

Provide wet-process porcelain insulators which are radio interference free.

a. Line post type insulators: ANSI C29.7, Class 57-1 (15 kV); Class 57-2 (25 kV) .

b. Suspension insulators: ANSI C29.2 Quantity per Phase, 2, Class 52-1 or 52-9 (15kV); Class 52-4 (25kV).

c. Spool insulators: ANSI C29.3, Class 53-2.

d. Guy strain insulators: ANSI C29.4, Class 54-2 (15 kV); Class 54-3 (25kV), except provide fiberglass type when used with underground terminal or when other interference problems exist.

e. Pin insulators: ANSI C29.5, Class 55-3 (15 kV); Class 55-6 (25 kV).

2.6 OVERHEAD CONDUCTORS, CONNECTORS AND SPLICES

Conductors of bare copper or aluminum conductor steel reinforced (ACSR) of sizes and types indicated. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486A-486B shall be used.

2.6.1 Solid Copper

ASTM B1, ASTM B2, and ASTM B3, hard-drawn, medium-hard-drawn, and soft-drawn, respectively. ASTM B8, stranded.

2.6.2 Aluminum Conductor Steel Reinforced (ACSR)

ASTM B232/B232M, aluminum.

2.6.3 Connectors and Splices

Connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Aluminum-composition, aluminum-composition to copper, and copper-to-copper shall comply with UL 486A-486B.

2.7 NEUTRAL-SUPPORTED SECONDARY AND SERVICE DROP CABLES

Service cables shall be copper, triplex or quadruplex with cross-linked polyethylene insulation on the phase conductors. Neutral shall be bare hard drawn copper and shall be the same size as the phase conductors unless otherwise indicated. Cables shall conform to NEMA WC 70 and ANSI/NEMA WC 71/ICEA S-96-659 for cross-linked polyethylene insulation.

2.8 GUY STRAND

ASTM A475 or KD D 7007, high-strength, Class A or B, galvanized strand steel cable. Guy strand shall be 16 mm (5/8 inch) in diameter with a minimum breaking strength of 26.8 KNewtons (6000 pounds). Provide guy terminations designed for use with the particular strand and developing at least the ultimate breaking strength of the strand.

2.9 ROUND GUY MARKERS

Vinyl or PVC material, yellow colored, 2440 mm (8 feet) long and shatter resistant at sub-zero temperatures.

2.9.1 Guy Attachment

Thimble eye guy attachment.

2.10 ANCHORS AND ANCHOR RODS

Anchors shall present holding area indicated on drawings as a minimum. Anchor rods shall be triple thimble-eye, 25 mm diameter by 2440 mm long (one inch diameter by 8 feet long). Anchors and anchor rods shall be hot dip galvanized.

2.10.1 Screw Anchors

Screw type swamp anchors having a manufacturer's rating in loose to medium sand/clay soil, Class 6 at least equal to rating indicated on contract drawings and documents and extra heavy pipe rods conforming to ASTM A53/A53M, Schedule 80, and couplings conforming to ASME B16.11, fitting Class 6000.

2.10.2 Plate Anchors

Minimum area and rated by manufacturer for force as indicated on contract drawings and documents or more in soils classified as medium dense coarse sand and sandy gravels; firm to stiff clays and silts.

2.10.3 Rock Anchors

Rock anchors having a manufacturer's rating of 160,130 Newtons (36,000 pounds).

2.11 GROUNDING AND BONDING

2.11.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467, zinc-coated steel ground rods conforming to IEEE C135.30 or solid stainless steel ground rods not less than 19 mm (3/4 inch) in diameter by 3.1 m (10 feet) in length. Sectional type rods may be used for rods 6.1 m (20 feet) or longer.

2.11.2 Grounding Conductors

ASTM B3. Provide soft drawn copper wire ground conductors a minimum No. 4 AWG. Ground wire protectors shall be PVC.

2.11.3 Grounding Connections

UL 467. Exothermic weld or compression connector.

2.12 SURGE ARRESTERS

IEEE C62.11, metal oxide, polymeric-housed, surge arresters arranged for crossarm or equipment mounting, RMS voltage rating, and Distribution, Intermediate, or Station class as indicated on contract drawings and documents.

2.13 FUSED CUTOUTS

Open or enclosed type fused cutouts conforming to IEEE C37.42. Type K or T fuses conforming to IEEE C37.42 with ampere ratings equal to 150 percent of the transformer full load rating. Open link type fuse cutouts are not acceptable.

2.14 CONDUIT RISERS AND CONDUCTORS

The riser shield shall be PVC containing a PVC back plate and PVC extension shield or a rigid galvanized steel conduit, as indicated, and conforming to UL 6. Provide conductors and terminations as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.15 TRANSFORMER (OVERHEAD-TYPE DISTRIBUTION)

a. IEEE C57.12.20.

b. Single phase, self-cooled, 65 degrees C. continuous temperature rise, two winding, 60 Hertz.

c. Insulating liquid:

Mineral oil: ASTM D3487, Type II, tested in accordance with ASTM D117. Provide identification of transformer as "non-PCB" and "Type II mineral oil" on the nameplate.

Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid on the nameplate.

The fluid shall be a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable fluids. The fluid shall meet the following fluid properties:

(1) Pour point: ASTM D97, less than -15 degrees C

(2) Aquatic biodegradation: EPA 712-C-98-075, 100 percent.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass.

d. Ratings:

(1) kVA: as indicated on contract drawings and documents.

(2) BIL: as indicated on contract drawings and documents.

(3) Primary voltage: as indicated on contract drawings and documents.

(4) Secondary voltage: as indicated on contract drawings and documents.

(5) Minimum Tested Impedance at 85 degrees C: as indicated on contract drawings and documents.

e. Single-phase connections:

(1) Connect primary: as indicated on contract drawings and documents.

(2) Provide transformer with high voltage bushing(s) as indicated on contract drawings and documents.

f. Three-phase connections:

(1) Connect primary: as indicated on contract drawings and documents.

(2) Connect secondary: as indicated on contract drawings and documents.

(3) Provide transformer with high voltage bushings as indicated on contract drawings and documents.

g. Taps:

(1) Provide four 2 1/2 percent full capacity taps, 2 above and 2 below rated primary voltage. Tap changer shall have external handle.

h. Corrosion Protection:

Paint coating system shall comply with IEEE C57.12.28 regardless of tank and cover material. Finish coat shall be light gray, ANSI color No. 70.

i. Show transformer kVA capacity using 65 mm (2 1/2 inch) Arabic numerals placed near the low-voltage bushings.

2.16 GROUP-OPERATED LOAD INTERRUPTER SWITCHES

2.16.1 Manually Operated Type (Switch Handle Operated)

Manually operated (switch handle operated) load interrupter switches shall comply with IEEE C37.32 and shall be of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators.

Switches shall be equipped with interrupters capable of interrupting currents equal to the switch's continuous current rating. Each switch shall be preassembled for the indicated configuration and mounting. Moving contacts shall be of the high-pressure, limited-area type, designed to ensure continuous surface contact. Switches shall be fused or non-fused as indicated. Switches shall be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Switch operating handles shall be located approximately 1.1 meters (3 feet 6 inches) above final grade. Insulation of switch operating mechanisms shall include both insulated interphase rod sections and insulated vertical shafts. Each handle shall be provided with a padlock arranged to lock the switch in both the open and the closed position.

2.16.2 Remotely Operated Type (Stored-Energy Actuator)

Remotely-operated, SF6 insulated load interrupter switches shall be rated in accordance with and comply with the requirements of IEEE C37.32 and shall be of the outdoor, three-pole, pole-mounted or crossarm-mounted type. Interrupter devices shall be SF6-insulated, puffer-type switches capable of interrupting currents equal to the switch continuous current ratings indicated. Switches shall utilize an electric motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. A switch-control unit shall be provided for push-button operation from the ground or for push-button operation from the ground and remote switch actuation via telemetry. The switch-control unit shall be pad-lockable, tamper-resistant, in a NEMA ICS 6, Type 3R, 4, 4X, or 4X-SS enclosure, which is connected to the switch actuator by a shielded control cable. Control power for closing and tripping shall be provided by a battery mounted in the control unit enclosure. The switch control unit shall be provided with a separate 120 volt ac circuit for the battery powered. Power for charging the operator mechanism may be 120 volt ac or battery powered. If operator mechanism charging power is from a battery, capacity shall be provided for a minimum of four sequential opening and closing operation without battery charging. The switch control unit shall be configured for supervisory, control, and data acquisition (SCADA) function, including local and remote operation. Voltage and current sensors shall be provided, one set for each phase, for monitoring of both normal and fault conditions. Switches shall be provided with visual indication of open switch contact for clearance and isolation purposes. Switch mechanisms shall be provided with provisions for grounding of nonenergized metal parts. The switch control unit shall be provided with a switch operations.

2.17 RECLOSER

IEC 62271-111. Recloser controller shall be electronically operated and utilize vacuum operating medium.

2.18 SECTIONALIZER

IEEE C37.63.

2.19 METERING EQUIPMENT

Pole mounted metering equipment shall include current transformers, potential transformers, watthour meter, meter test switch block, metering enclosure, wire, conduit and fittings.

2.19.1 Potential Transformers

Potential transformers shall be rated for outdoor service fitted for crossarm mounting and secondary connection box for conduit connection. Voltage rating shall be 22.9 kV to 120 volts ac, 60 Hz. Transformers shall conform to the requirements of IEEE C57.13 BIL rating as indicated on contract drawings and documents and accuracy Class 0.3 (min.) at burden Y.

2.19.2 Current Transformers

Current transformers shall be rated for outdoor service with crossarm mounting and secondary connection box for conduit connection and conform to requirements of IEEE C57.13. Voltage, current, and BIL ratings shall be as indicated on contract drawings and documents. Accuracy Class and minimum Rating Factor (RF) at 30 degrees C (86 degrees F) as shown in tables below.

Primary Amp Rating (of CT)	Accuracy Class
200	0.3 thru B-0.1
300-400	0.3 thru B-0.2
600-1200	0.3 thru B-0.5
1500	0.3 thru B-0.9
2000-3000	0.3 thru B-1.8

RATIO	RF at 30 degrees C
200/5	4.0
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5
1500/5	1.5
2000/5	1.5
3000/5	1.33

2.19.3 Watthour Meter

Provide meter with provisions for future pulse initiation.

a. Meters: NEMA/ANSI C12.10 and ANSI C12.1; when providing meter with electronic time-of-use register.

(1) Form: 5A, 5S, 6A, or 6S.

(2) Element: 2, 2 1/2, or 3.

(3) Voltage: 120 volts.

(4) Current: 2 1/2 amperes.

(5) Frequency: 60 hertz.

(6) Kilowatt hour register: 5 dial or 5 digit type.

b. Demand register:

(1) Solid state type.

(2) Meter reading multiplier:

(a) Indicate multiplier on the meter face.

(b) Provide multiplier in even hundreds.

(3) Demand interval length: shall be programmed for 15 minutes with rolling demand up to six subintervals per interval.

c. Mounting:

(1) Provide meter with matching socket per ANSI C12.7 with automatic current short-circulating device or "A" base type mounting.

2.19.4 Meter Test Block

Provide meter test block with T or 10 pole group of open knife type switches designed for the isolation of metering devices at meter location by opening each circuit individually. Current switches shall short circuit current supply before opening meter circuit. Switch handles of potential switches shall be black. Switch handles of current switches shall be red.

2.19.5 Metering Enclosure

Metering enclosure shall be of galvanized steel, weatherproof construction with pole mounting bracket, and 19 mm (3/4 inch) exterior plywood, full size backboard and hinged door arranged for padlocking in closed position. Internal space shall be adequate to house equipment and wiring but not smaller than 510 by 760 by 280 mm (20 by 30 by 11 inches) deep. Paint metal manufacturer's standard finish.

2.20 CAPACITORS

Capacitor equipment shall comply with IEEE 18 and shall be of the three-phase, grounded-wye, outdoor type rated for continuous operation and automatically switched. Equipment shall be suitable for mounting on a single pole. Polychlorinated biphenyl and tetrachloroethylene (perchloroethylene) shall not be used as the dielectric. Equipment shall be rated for the system voltage. The indicated kvars shall be automatically switched by control providing the indicated number of steps and switching the indicated kvar. Necessary transformers shall be provided for sensing circuit variations and for low-voltage control. Oil-immersed switches shall be provided for automatic switching of capacitors, and shall be electrically separate from ungrounded capacitor enclosures and metal frames. Installations shall include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Fuse link ratings shall be in accordance with the manufacturer's recommendations. Capacitor equipment, except for low-voltage control and primary fuse cutouts, shall be assembled and coordinated by one manufacturer. Units, including metal pole-mounting supports and hardware, shall be shipped in complete sections ready for connection at the site. Low-voltage equipment shall be socket or cabinet type, mounted on the pole approximately 1.2 m (4 feet) above grade, shall be connected with the necessary wiring in conduit to capacitor equipment, and shall be provided with secondary arrester protection against switching surges when recommended by the manufacturer.

2.21 VOLTAGE REGULATOR

Voltage regulators shall comply with IEEE C57.15 and shall be of the outdoor, self-cooled, 55/65 degrees C temperature rise, single-phase type. Windings and the load-tap-changing mechanism shall be mineral-oil-immersed. When operating under load, a regulator shall provide plus and minus 10 percent automatic voltage regulation in approximately 5/8 percent steps, with 16 steps above and 16 steps below rated voltage. Automatic control equipment shall provide Class 1 accuracy. Bypass surge arresters shall be suitable for a grounded system and for the associated regulator voltage. Station or Intermediate class surge arresters, as indicated on contract drawings and documents, shall be mounted next to each incoming line bushing on a regulator tank-mounted bracket and connected to a surge arrester ground pad-mounted on the regulator tank.

2.21.1 Ratings

Ratings for maximum voltage, BIL, and current at 60 Hz shall be as indicated on contract drawings and documents.

2.21.2 Bypass and Isolation Switches

Switches shall be of the outdoor, hook stick-operated, single-pole, single-throw, vertical-break type suitable for the indicated mounting. Switches shall be of a type designed to provide bypass of a single-phase regulator circuit by an integral sequence which always occurs when each switch is opened or closed. Each opening sequence shall initially bypass the single-phase regulator circuit, then open the input and output circuits, and finally interrupt the exciting current. Opening any single-phase regulator circuit shall not be possible until after the bypass circuit is closed. Following ratings at 60 Hz shall be in accordance with IEEE C37.41 and as indicated on contract drawings and documents.

Maximum voltageNominal voltage classBILMomentary asymmetrical current in the closed positionMomentary asymmetrical current in the bypass positionContinuous and interrupting current2.21.3 Miscellaneous

Standard accessories and components in accordance with IEEE C57.15shall be provided. Single-phase units shall be provided with additional components and accessories required by IEEE C57.15 for three-phase units.

2.22 ELECTRICAL TAPES

Tapes shall be UL listed for electrical insulation and other purposes in wire and cable splices. Terminations, repairs and miscellaneous purposes, electrical tapes shall comply with UL 510.

2.23 CAULKING COMPOUND

Compound for sealing of conduit risers shall be of a putty-like consistency workable with hands at temperatures as low as 2 degrees C (35 degrees F), shall not slump at a temperature of 150 degrees C (300 degrees F), and shall not harden materially when exposed to air. Compound shall readily caulking or adhere to clean surfaces of the materials with which it is designed to be used. Compound shall have no injurious effects upon the workmen or upon the materials.

2.24 NAMEPLATES

2.24.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate.

2.24.2 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

2.25 SOURCE QUALITY CONTROL

2.25.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Test Instrument Calibration

a. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels shall be visible on all test equipment.

e. Calibrating standard shall be of higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

   (1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

   (2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.25.2 Routine and Other Tests

IEEE C57.12.00 and IEEE C57.12.90. Routine and other tests shall be performed by the manufacturer on the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests shall be as follows:

a. Polarity

b. Ratio

c. No-load losses (NLL) and excitation current

d. Load losses (LL) and impedance voltage

e. Dielectric

   (1) Impulse

   (2) Applied voltage

   (3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Provide overhead pole line installation conforming to requirements of IEEE C2 for Grade B or C construction of overhead lines in light, medium, or heavy loading districts and NFPA 70 for overhead services. Provide material required to make connections into existing system and perform excavating, backfilling, and other incidental labor. Consider street, alleys, roads and drives "public." Pole configuration shall be as indicated.

3.1.1 Overhead Service

Terminate overhead service conductors into buildings at service entrance fittings or weather head outside building. Installation and connection of service entrance equipment to overhead service conductor is included in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Drip loops shall be formed on conductors at entrances to buildings, cabinets, or conduits.

3.1.2 Tree Trimming

Where lines pass through trees, trees shall be trimmed at least 4.5 meters (15 feet) clear on both sides horizontally and below for medium-voltage lines, and 1.5 meters (5 feet) clear on both sides horizontally and below for other lines. No branch shall overhang horizontal clearances. Where trees are indicated to be removed to provide a clear right-of-way, clearing is specified in Section 31 11 00 CLEARING AND GRUBBING.

3.1.3 Steel and Concrete Pole Setting

Poles shall be mounted on cast-in-place or power-installed screw foundations. Concrete poles shall be embedded in accordance with the details shown. Conduit elbows shall be provided for cable entrances into pole interiors.

3.1.3.1 Cast-In-Place Foundations

Concrete foundations, sized as indicated, shall have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. After the concrete has cured, pole anchor bases shall be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles shall be set plumb. Anchor bolts shall be the manufacturer's standard, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

3.1.3.2 Power-Installed Screw Foundations

Power-installed screw foundations may be used if they have the required strength, mounting-bolt, and top plate dimensions. Screw foundations shall be of at least 6.4 mm (1/4 inch) thick structural steel conforming to ASTM A36/A36M or KS D 3555 and hot-dip galvanized in accordance with ASTM A123/A123M. Conduit slots in screw foundation shafts and top plates shall be marked to indicate orientation. Design calculations indicating adequate strength shall be approved before installation of screw foundation is permitted. Calculations shall be submitted in accordance with the design data portion of paragraph entitled "SUBMITTALS."

3.1.4 Anchors and Guys

Place anchors in line with strain. The length of the guy lead (distance from base of pole to the top of the anchor rod) shall be as indicated.

3.1.4.1 Setting Anchors

Set anchors in place with anchor rod aligned with, and pointing directly at, guy attachment on the pole with the anchor rod projecting 150 to 230 mm (6 to 9 inches) out of ground to prevent burial of rod eye.

3.1.4.2 Backfilling Near Anchors

Backfill plate, expanding, concrete, or cone type anchors with tightly tamped coarse rock 610 mm (2 feet) immediately above anchor and then with tightly tamped earth filling remainder of hole.

3.1.4.3 Screw Anchors

Install screw anchors by torquing with boring machine.

3.1.4.4 Swamp Anchors

Install swamp anchors by torquing with boring machine or wrenches, adding sections of pipe as required until anchor helix is fully engaged in firm soil.

3.1.4.5 Rock Anchors

Install rock anchors minimum depth 305 mm (12 inches) in solid rock.

3.1.4.6 Guy Installation

Provide guys where indicated, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners and dead-ends. Where single guy will not provide the required strength, two or more guys shall be provided. Where guys are wrapped around poles, at least two guy hooks shall be provided. Provide pole shims where guy tension exceeds 27,000 Newtons (6000 pounds). Guy clamps 152 mm (6 inches) in length with three 16 mm (5/8 inch) bolts, or offset-type guy clamps, or approved guy grips shall be provided at each guy terminal. Securely clamp plastic guy marker to the guy or anchor at the bottom and top of marker. Complete anchor and guy installation, dead end to dead end, and tighten guy before wire stringing and sagging is begun on that line section. Provide strain insulators at a point on guy strand 2435 mm (8 feet) minimum from the ground and 1825 mm (6 feet) minimum from the surface of pole. Effectively ground and bond guys to the system neutral.

3.1.5 Hardware

Provide hardware with washer against wood and with nuts and lock nuts applied wrench tight. Provide locknuts on threaded hardware connections. Locknuts shall be M-F style and not palnut style.

3.1.6 Grounding

Unless otherwise indicated, grounding shall conform to IEEE C2 and NFPA 70. Pole grounding electrodes shall have a resistance to ground not exceeding 25 ohms. When work in addition to that indicated or specified is directed in order to obtain specified ground resistance, provisions of the contract covering changes shall apply.

3.1.6.1 Grounding Electrode Installation

Grounding electrodes shall be installed as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be located approximately 900 mm (3 feet) out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm (1 foot) below finished grade. Multiple rods shall be evenly spaced at least 3 m (10 feet) apart and connected together 600 mm (2 feet) below grade with a minimum No. 6 bare copper conductor.

b. Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.

c. Ground resistance - The maximum resistance of a driven ground rod or plate electrode shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes interconnected with grounding conductors as indicated, to achieve the specified ground resistance. The additional electrodes will be up to three, 3 m (10 feet(rods spaced a minimum of 3 m (10 feet)apart driven perpendicular to grade. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.1.6.2 Grounding Electrode Conductors

On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Neutrals, surge arresters, and equipment grounding conductors shall be bonded to this conductor. For single-grounded or ungrounded systems, provide a grounding electrode conductor for the surge arrester and equipment grounding conductors and a separate grounding electrode conductor for the secondary neutrals. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm (2 feet). On metal poles, a preformed galvanized steel strap, 15.9 mm (5/8 inch) wide by 0.853 (22 gauge) minimum by length, secured by a preformed locking method standard with the manufacturer, shall be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 1.5 m (5 feet) with one band not more than 75 mm (3 inches) from each end of the vertical grounding electrode conductor. Grounding electrode conductors shall be sized as indicated. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor as indicated. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.1.6.3 Grounding Electrode Connections

Make above grade grounding connections on pole lines by exothermic weld or by using a compression connector. Make below grade grounding connections by exothermic weld. Make exothermic welds strictly in accordance with manufacturer's written recommendations. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable. No mechanical connectors are required at exothermic weldments. Compression connectors shall be type that uses a hydraulic compression tool to provide correct pressure. Provide tools and dies recommended by compression connector manufacturer. An embossing die code or similar method shall provide visible indication that a connector has been fully compressed on ground wire.

3.1.6.4 Grounding and Grounded Connections

a. Where no primary or common neutral exists, surge arresters and frames of equipment operating at over 750 volts shall be bonded together and connected to a dedicated primary grounding electrode.

b. Where no primary or common neutral exists, transformer secondary neutral bushing, secondary neutral conductor, and frames of equipment operating at under 750 volts shall be bonded together and connected to a dedicated secondary grounding electrode.

c. When a primary or common neutral exists, connect all grounding and grounded conductors to a common grounding electrode.

3.1.6.5 Protective Molding

Protect grounding conductors which are run on surface of wood poles by PVC molding extending from ground line throughout communication and transformer spaces.

3.1.7 CONDUCTOR INSTALLATION

3.1.7.1 Line Conductors

Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Conductors shall be handled with care necessary to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening conductor or any damage to insulation or impairing its conductivity. Remove damaged sections of conductor and splice conductor. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.1.7.2 Connectors and Splices

Conductor splices, as installed, shall exceed ultimate rated strength of conductor and shall be of type recommended by conductor manufacturer. No splice shall be permitted within 3050 mm (10 feet) of a support. Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Noninsulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

3.1.7.3 Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as specified in TABLE I.

TABLE I - TIE-WIRE REQUIREMENTS	
CONDUCTOR Copper (AWG)	TIE WIRE Soft-Drawn Copper (AWG)
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2
AAC, AAAC, or ACSR (AWG	AAAC OR AAC (AWG)
Any size	6 or 4

3.1.7.4 Armor Rods

Armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 61 m, (200 feet), flat aluminum armor rods may be used. Flat armor rods, not less than 762.0 micrometers by 6.4 mm (0.03 by 0.25 inch) shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 1.3 by 7.6 mm (0.05 by 0.30 inches). For span lengths of 61 m (200 feet) or more, preformed round armor rods shall be used.

3.1.7.5 Ties

Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.

3.1.7.6 Low-Voltage Insulated Cables

Low-voltage cables shall be supported on clevis fittings using spool insulators. Dead-end clevis fittings and suspensions insulators shall be provided where required for adequate strength. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 15.9 mm (5/8 inch) through-bolts. Secondary racks may be used when installed on wood poles and where the span length does not exceed 61 m (200 feet). Secondary racks shall be two-, three-, or four-wire, complete with spool insulators. Racks shall meet strength and deflection requirements for heavy-duty steel racks, and shall be rounded and smooth to avoid damage to conductor insulation. Each insulator shall be held in place with a 15.9 mm (5/8 inch) button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Racks for dead-ending four No. 4/0 AWG or four larger conductors shall be attached to poles with three 15.9 mm (5/8 inch) through-bolts. Other secondary racks shall be attached to poles with at least two 15.9 mm (5/8 inch) through-bolts. Minimum vertical spacing between conductors shall not be less than 200 mm (8 inches).

3.1.7.7 Reinstalling Conductors

Existing conductors to be reinstalled or resagged shall be strung to "final" sag table values indicated for the particular conductor type and size involved.

3.1.7.8 New Conductor Installation

String new conductors to "initial" sag table values recommended by the manufacturer for conductor type and size of conductor and ruling span indicated.

3.1.7.9 Fittings

Dead end fittings, clamp or compression type, shall conform to written recommendations of conductor manufacturer and shall develop full ultimate strength of conductor.

3.1.7.10 Aluminum Connections

Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose. Keep a copy of manufacturer's instructions for applying these fittings at job site for use of the inspector.

3.1.8 Pole Mounted Metering Equipment

3.1.8.1 Primary Meters

Install primary metering transformers as indicated on contract drawings and documents. Make connections to metering circuits within each transformer conduit connection box.

3.1.8.2 Installing Meter System

Metering enclosure shall house kWh meter and meter test block. Secure the enclosure to pole at a height of 1825 mm (6 feet) above grade to center of the enclosure. Ground enclosure.

a. Connect meter as indicated.

b. Connect meter test block between meter and metering transformers to isolate meter for removal, test or adjustment.

c. Phase sequence and color code of potential and current leads shall be identical. Mark wires which are connected to transformer terminals identified with polarity marks (dots) by a colored plastic tape around the wire at each end.

d. No splices are permissible in metering circuits. Wire shall be trained at sides and bottom of enclosure back board and secured by plastic wraps.

3.1.9 Pole Top Switch Installation

Install pole top switch strictly according to manufacturer's installation drawings and information.

3.1.9.1 Operating Handle

Locate approximately 1520 mm (5 feet) above ground on field side of pole.

3.1.10 Recloser

Install recloser(s) strictly in accordance with manufacturer's instructions.

3.1.11 Sectionalizer

Install sectionalizer(s) strictly in accordance with manufacturer's instructions.

3.1.12 Risers

Secure galvanized steel conduits on poles by two hole galvanized steel pipe straps spaced as indicated and within 910 mm (3 feet) of any outlet or termination. Ground metallic conduits. Secure PVC riser shields on poles as indicated.

3.2 TRANSFORMER INSTALLATION

Transformers shall be carefully installed so as not to scratch finishes or damage bushings. Transformers shall be installed in accordance with the manufacturer's instructions. After installation, surfaces shall be inspected and scratches shall be touched up with a finish provided by the transformer manufacturer for this purpose.

3.3 CROSSARM MOUNTING

Crossarms shall be bolted to poles with 15.9 mm (5/8 inch) through-bolts with square washers at each end. Bolts shall extend not less than 3 mm (1/8 inch) nor more than 50 mm (2 inches) beyond nuts. On single crossarm construction, the bolt head shall be installed on the crossarm side of the pole. Metal crossarm braces shall be provided on crossarms. Flat braces may be provided for 2.4 m (8 foot) crossarms and shall be 6.4 by 31.8 mm (1/4 by 1-1/4 inches), not less than 700 mm (28 inches) in length. Flat braces shall be bolted to arms with 9.5 mm 3/8 inch carriage bolts with round or square washers between boltheads and crossarms, and secured to poles with 50.8 by 101.6 mm (1/2 by 4 inch) lag screws after crossarms are leveled and aligned. Angle braces are required for 3.1 m (10 foot) crossarms and shall be 1.5 m (60 inch) span by 457.2 mm (18 inch) drop formed in one piece from 38.1 by 38.1 by 4.8 mm (1-1/2 by 1-1/2 by 3/16 inch) angle. Angle braces shall be bolted to crossarms with 50.8 mm (1/2 inch) bolts with round or square washers between boltheads and crossarms, and secured to poles with 15.9 mm (5/8 inch) through-bolts. Double crossarms shall be securely held in position by means of 15.9 mm (5/8 inch) double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.

3.3.1 Line Arms and Buck Arms

Line arms and buck arms shall be set at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms shall bisect angles of turns of less than 45 degrees. Dead-end assemblies shall be used for turns where shown. Buck arms shall be installed as indicated on contract drawings and documents at corners and junction poles. Double crossarms shall be provided at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Double crossarms shall be provided at each line-crossing structure and where lines not attached to the same pole cross each other.

3.3.2 Equipment Arms

Equipment arms shall be set parallel or at right angles to lines as required to provide climbing space. Equipment arms shall be located below line construction to provide necessary wire and equipment clearances.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.6 FIELD QUALITY CONTROL

3.6.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 10 days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.6.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.6.3 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, and shall not exceed the recommendations of IEEE 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.6.4 Sag and Tension Test

The Contracting Officer shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.6.5 Low-Voltage Cable Test

For underground secondary or service laterals from overhead lines, the low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energizing. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters)(R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet))

Each cable failing this test shall be repaired or replaced. The repaired cable shall then be retested until failures have been eliminated.

3.6.6 Pre-Energizing Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energizing. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

Capacitors.

Switches.

3.6.7 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.7.1 Overhead-Type Distribution Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

(4) Perform specific inspections and mechanical tests as recommended by manufacturer.

(5) Verify correct equipment grounding.

b. Electrical tests

(1) Insure that the series-multiple voltage-changing switch is in the correct position. Transformers are normally shipped in the series position.

(2) Perform insulation-resistance tests.

(3) Perform continuity test.

(4) Set tap changer to provide a secondary voltage of 120/240 or 120/208.

3.6.7.2 Pole Top Interrupter Switch

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify appropriate equipment grounding.

(4) Perform mechanical operator tests in accordance with manufacturer's instructions.

(5) Verify correct blade alignment, blade penetration, travel stops,

arc interrupter operation, and mechanical operation.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform dc over-potential tests.

(3) Perform contact-resistance tests across each switch blade.

3.6.7.3 Reclosers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the recloser and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test

(3) Sample insulating liquid. Sample shall be tested for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Test protective functions.

(5) Perform vacuum bottle integrity test (overpotential) across each vacuum bottle with the recloser in the open position in strict accordance with manufacturer's instructions.

(6) Perform overpotential tests.

(7) Determine time delay for each programmed reclosing interval.

(8) Verify lockout for unsuccessful reclosing.

(9) Determine reset time.

(10) Verify instantaneous overcurrent lockout.

3.6.7.4 Sectionalizers

a. Visual and Mechanical inspection

(1) Compare equipment nameplate data with approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect alignment and grounding.

(4) Perform mechanical operation and contact alignment tests on both the sectionalizer and its operating mechanism in accordance with manufacturer's instructions.

(5) Verify tightness of accessible bolted electrical connections.

(6) Inspect for correct insulating liquid level.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Perform a contact resistance test.

(3) Sample insulating liquid. Sample shall be tested for:

(a) Dielectric breakdown voltage

(b) Color

(c) Visual condition

(4) Perform overpotential tests.

(5) Test sectionalizer counting function.

(6) Test sectionalizer lockout function.

(7) Test for reset timing on trip actuator.

3.6.7.5 Potential Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Verify correct connection.

(3) Verify that adequate clearances exist between primary and secondary circuit wiring.

(4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that all required grounding and shorting connections provide good contact.

(6) Verify correct fuse sizes.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform turns-ratio tests.

3.6.7.6 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.6.7.7 Metering

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Verify accuracy of meters at 25 percent, 50 percent, 75 percent, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published

data.

(3) Verify all instrument multipliers.

3.6.7.8 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.6.8 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least three times, demonstrating satisfactory operation each time.

3.6.9 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2011) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C62.61	(1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata

3-4 2014; AMD 4-6 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607	(2002a) Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
TIA-455-107	(1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set
TIA-455-46A	(1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers
TIA-455-78-B	(2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-492E000	(1996; R 2002) Sectional Specification for Class IVd Nonzero-Dispersion Single-Mode Optical Fibers for the 1550 nm Window
TIA-526-14	(2010b) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2002; R 2008) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-2	(2009c; Errata 2010) Commercial Building Telecommunications Cabling Standard - Part 2: Balanced Twisted Pair Cable Components
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.3	(2008; Corrections 2008) Optical Fiber Cabling Components Standard
TIA-569	(2012c; Addendum 1 2013; Errata 2013) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber
TIA/EIA-598	(2005c) Optical Fiber Cable Color Coding
TIA/EIA-606	(2002a; Errata 2007; R 2007; Adm 1 2008) Administration Standard for the Telecommunications Infrastructure

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-640	(1995) Design of Buried Plant, Physical Considerations
RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)
RUS Bull 1753F-401	(1995) Splicing Copper and Fiber Optic Cables (PC-2)
RUS Bull 345-50	(1979) Trunk Carrier Systems (PE-60)
RUS Bull 345-65	(1985) Shield Bonding Connectors (PE-65)
RUS Bull 345-72	(1985) Filled Splice Closures (PE-74)
RUS Bull 345-83	(1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)

UNDERWRITERS LABORATORIES (UL)

UL 497	(2001; Reprint Apr 2009) Protectors for Paired Conductor Communication Circuits
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 83	(2014) Thermoplastic-Insulated Wires and

1.2 RELATED REQUIREMENTS

Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM, Section 33 71 01, OVERHEAD TRANSMISSION AND DISTRIBUTION, and Section 33 70 02.00 10, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-C.1, TIA-568-2, TIA-568-C.3, TIA-569, TIA/EIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the new facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL

PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G

Telecommunications Entrance Facility Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Cable splices, and connectors

Closures

Building protector assemblies; G

Protector modules

Cross-connect terminal cabinets; G

Spare Parts

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation tests

Acceptance tests

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

SD-08 Manufacturer's Instructions

Building protector assembly installation

Fiber Optic Splices

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data

SD-11 Closeout Submittals

Record Documentation

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA/EIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings. Update existing telecommunication Outside Plant T0 drawings to include information modified, deleted or added as a result of this installation in accordance with TIA/EIA-606. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications in accordance with TIA/EIA-606 that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings. Provide T3 drawings for EF Telecommunications as specified in the paragraph TELECOMMUNICATIONS SPACE DRAWINGS of Section 27 10 00 BUILDING

TELECOMMUNICATIONS CABLING SYSTEMS. The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals. Drawings shall be prepared as discussed in Section 01 33 00 SUBMITTAL PROCEDURES.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 10 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel require approval from the Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, TIA-568-C.1, TIA-568-2 and TIA-568-C.3. In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least10 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA-568-C.1 and RUS Bull 1753F-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 1 year prior to bid opening. The 1-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 1-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.4.1 Alternative Qualifications

Products having less than a 1-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 3000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 152 or 305 meter (500 or 1000 feet) length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA/EIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. A licensed copy of the cable management software, including documentation, shall be provided. Update existing record documentation to reflect campus distribution T0 drawings and T3 drawing schedule information modified, deleted or added as a result of this installation. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA/EIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA/EIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA/EIA-606. Documentation shall include only the required data fields as a minimum in accordance with TIA/EIA-606.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.8.2 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Spare parts shall be provided no later than the start of field testing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained 5 pin screw type unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturer's instructions for building protector assembly installation. Provide copper cable interconnecting hardware as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.2.2 Protector Modules

Provide in accordance with UL 497 three or two-electrode gas tube or solid state type 5 pin screw type rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be heavy duty, A>10kA, B>400, C>65A maximum duty, A>20kA, B>1000, C>200A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.2.3 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Aerial Cable Closures

Provide cable closure assembly consisting of a frame with clamps, a lift-off polyethylene cover, cable nozzles, and drop wire rings. Closure shall be suitable for use on Figure 8 cables. Closures shall be free breathing and suitable for housing of the type indicated splices of non-pressurized communications cables and shall be sized as indicated on contract drawings and documents. The closure shall be constructed with ultraviolet resistant PVC.

2.3.1.2 Underground Cable Closures

a. Aboveground: Provide aboveground closures constructed of not less than 14 gauge steel or ultraviolet resistant PVC and acceptable for pole or stake mounting in accordance with RUS 1755.910. Closures shall be sized and contain a marker as indicated on contract drawings and documents. Covers shall be secured to prevent unauthorized entry.

b. Direct burial: Provide buried closure suitable for enclosing a straight, butt, and branch splice in a container into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity in the buried environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with

RUS Bull 345-72.

c. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which can be poured an encapsulating compound. Closure shall be of suitable thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.2 Fiber Optic Closures

2.3.2.1 Aerial

Provide aerial closure that is free breathing and suitable for housing splice organizer of non -pressurized cables. Closure shall be constructed from heavy PVC with ultraviolet resistance.

2.3.2.2 Direct Burial

Provide buried closure suitable to house splice organizer in protective housing into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity, when metallic, in buried environment. Encapsulating compound shall be reenterable and shall not alter chemical stability of the closure.

2.3.2.3 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure shall be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure.

2.4 PAD MOUNTED CROSS-CONNECT TERMINAL CABINETS

Provide in accordance with RUS 1755.910 and the following:

a. Constructed of 14 gauge steel.

b. Equipped with a double set of hinged doors with closed-cell foam weatherstripping. Doors shall be locked and contain a marker as indicated on contract drawings and documents.

c. Equipped with spool spindle bracket, mounting frames, binding post log, and jumpering instruction label, and load coil mounting provisions.

d. Complete with cross-connect modules to terminate number of pairs as indicated on contract drawings and documents.

e. Sized as indicated on contract drawings and documents.

2.5 CABLE SPLICES, AND CONNECTORS

2.5.1 Copper Cable Splices

Provide multipair, foldback, in-line, or single pair, in-line, butt, or box tap splices of a moisture resistant, two or three-wire insulation displacement connector held rigidly in place to assure maximum continuity in accordance with RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

2.5.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 1.65 mm (0.065 inch). Fill connector with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

2.5.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion or mechanical methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of 40.0 db max for single mode fiber when tested in accordance with TIA-455-107. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.5.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. Splice organizer shall allow for a minimum of 1 m (3 feet) of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

2.5.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with RUS Bull 345-65.

2.6 CONDUIT

Provide conduit as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.7 PLASTIC INSULATING TAPE

UL 510.

2.8 WIRE AND CABLE

2.8.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.8.1.1 Underground

Provide filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390 or RUS 1755.890.

2.8.1.2 Aerial

Provide filled cable meeting the requirements of ICEA S-99-689 ICEA S-98-688, and RUS 1755.390 except that it shall be suitable for aerial installation and shall be Figure 8 distribution wire with 26,700 N (6,000 pound) Class A galvanized steel or 26,700 N (6,000 pound) aluminum-clad steel strand.

2.8.1.3 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390.

2.8.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAA or single-mode, 8/125-um, 0.10 aperture 1550 nm fiber optic cable in accordance with TIA-492E000 including any special requirements made necessary by a specialized design. Provide 12 optical fibers. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598

2.8.2.1 Strength Members

Provide central or non-central, non-metallic or metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.8.2.2 Shielding or Other Metallic Covering

Provide copper, copper alloy or copper and steel laminate, , single tape covering or shield in accordance with ICEA S-87-640, unless otherwise indicated in contract drawings and documents.

2.8.2.3 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.8.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA J-STD-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.9 T-SPAN LINE TREATMENT REPEATERS

Provide pedestal mounted repeaters with non-pressurized housings, sized and placed as indicated on contract drawings and documents, meeting the requirements of RUS Bull 345-50.

2.10 POLES AND HARDWARE

Provide poles and hardware as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

2.11 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be stainless steel or polyethylene and labeled in accordance with TIA/EIA-606. Handwritten labeling is unacceptable.

2.11.1 Stainless Steel

Provide stainless steel, cable tags 41.25 mm (1 5/8 inches) in diameter 1.58 mm (1/16 inch) thick minimum, and circular in shape. Tags shall be die stamped with numbers, letters, and symbols not less than 6.35 mm (0.25 inch) high and approximately 0.38 mm (0.015 inch) deep in normal block style.

2.11.2 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 22.4 MPa (3250 pounds per square inch); and that are two millimeter (0.08 inch) thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C (170 degrees F). Provide 1.3 mm (0.05 inch) (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 778.75 N (175 pounds). The cable tags shall have black block letters, numbers, and symbols 25 mm (one inch) high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.12 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED

WARNING AND IDENTIFICATION TAPE in Section 31 00 00, EARTHWORK.

2.13 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper.

2.14 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.15 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment as indicated on contract drawings and documents. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

2.16 TESTS, INSPECTIONS, AND VERIFICATIONS

2.16.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568-C.1 and TIA-568-C.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions, IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Direct Burial System

Installation shall be in accordance with RUS Bull 1751F-640. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of 610 mm (24 inches) below finished grade. Trenches shall be not less than 155 mm (6 inches) wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than 915 mm (36 inches). Where two or more cables are laid parallel in the same trench, space laterally at least 78 mm (3 inches) apart. When rock is encountered, remove it to a depth of at least 78 mm (3 inches) below the cable and fill the space with sand or clean earth free from particles larger than 6 mm (1/4 inch). Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00 EARTHWORK.

3.1.3.1 Cable Placement

a. Separate cables crossing other cables or metal piping from the other cables or pipe by not less than 78 mm (3 inches) of well tamped earth. Do not install circuits for communications under or above traffic signal loops.

b. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

c. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

d. Leave a horizontal slack of approximately 915 mm (3 feet) in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought aboveground. Where cable is brought aboveground, leave additional slack to make necessary connections.

3.1.3.2 Identification Slabs Markers

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately 508 mm (20 inches) square by 155 mm (6 inches) thick.

3.1.3.3 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 53 mm (2 inches) thick on the floor of the trench before placing the cable or wire. The backfill for at least 103 mm (4 inches) above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 610 mm (24 inches) in depth, a protective cover of metal or concrete shall be used.

3.1.4 Cable Protection

Provide direct burial cable protection in accordance with NFPA 70 and as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of 155 mm per 305 mm (6 inches per 12 inches) burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40 percent of cross-sectional area, or in concrete encased 103 mm (4 inches) PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 155 mm (6 inches) lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.4.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.1.5 Underground Duct

Provide underground duct and connections to existing manholes, handholes, concrete pads, and existing ducts as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND with any additional requirements as specified herein.

3.1.6 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.1.7 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.8 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.8.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.8.2 Pulling Eyes

Equip cables 32 mm (1.25 inches) in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 32 mm (1.25 inches) with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 19 mm (3/4 inch) links between pulling-in eyes or grips and pulling strand.

3.1.8.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 1220 mm (4 feet). In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.

3.1.9 Aerial Cable Installation

Pole installation shall be as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Where physical obstructions make it necessary to pull distribution wire along the line from a stationary reel, use cable stringing blocks to support wire during placing and tensioning operations. Do not place ladders, cable coils, and other equipment on or against the distribution wire. Wire shall be sagged in accordance with the data shown. Protect cable installed outside of building less than 2.5 meters (8 feet) above finished grade against physical damage.

3.1.9.1 Figure 8 Distribution Wire

Perform spiraling of the wire within 24 hours of the tensioning operation. Perform spiraling operations at alternate poles with the approximate length of the spiral being 4575 mm (15 feet). Do not remove insulation from support members except at bonding and grounding points and at points where ends of support members are terminated in splicing and dead-end devices. Ground support wire at poles to the pole ground.

3.1.9.2 Suspension Strand

Place suspension strand as indicated on contract drawings and documents. Tension in accordance with the data indicated. When tensioning strand, loosen cable suspension clamps enough to allow free movement of the strand. Place suspension strand on the road side of the pole line. In tangent construction, point the lip of the suspension strand clamp toward the pole. At angles in the line, point the suspension strand clamp lip away from the load. In level construction place the suspension strand clamp in such a manner that it will hold the strand below the through-bolt. At points where there is an up-pull on the strand, place clamp so that it will support strand above the through-bolt. Make suspension strand electrically continuous throughout its entire length, bond to other bare cables suspension strands and connect to pole ground at each pole.

3.1.9.3 Aerial Cable

Keep cable ends sealed at all times using cable end caps. Take cable from reel only as it is placed. During placing operations, do not bend cables in a radius less than 10 times the outside diameter of cable. Place temporary supports sufficiently close together and properly tension the cable where necessary to prevent excessive bending. In those instances where spiraling of cabling is involved, accomplish mounting of enclosures for purposes of loading, splicing, and distribution after the spiraling operation has been completed.

3.1.10 Cable Splicing

3.1.10.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.10.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.2 dB for fusion splices or not greater than 0.4 db for mechanical splices.

3.1.11 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meets the requirements of RUS Bull 1751F-815.

3.1.12 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA J-STD-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.12.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.12.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.12.3 Campus Distributor Grounding

a. Protection assemblies: Mount CD protector assemblies directly on the telecommunications backboard, in the telecommunications rack or cabinet as indicated in contract drawings and documents. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

3.1.13 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the telecommunications contractor.

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with TIA/EIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using thermal ink transfer process or laser printer.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The labeling of telecommunications cable tag identifiers shall be in accordance with TIA/EIA-606. Tag legend shall be as indicated on contract drawings and documents. Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with TIA/EIA-606.

3.3 FIELD APPLIED PAINTING

Provide ferrous metallic enclosure finishes in accordance with the following procedures. Ensure that surfaces are dry and clean when the coating is applied. Coat joints and crevices. Prior to assembly, paint surfaces which will be concealed or inaccessible after assembly. Apply primer and finish coat in accordance with the manufacturer's recommendations. Provide ferrous metallic enclosure finishes as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.1 Cleaning

Clean surfaces in accordance with SSPC SP 6/NACE No.3.

3.3.2 Priming

Prime with a two component polyamide epoxy primer which has a bisphenol-A base, a minimum of 60 percent solids by volume, and an ability to build up a minimum dry film thickness on a vertical surface of 0.127 mm (5.0 mils). Apply in two coats to a total dry film thickness of 0.127 to 0.2 mm (5 to 8 mils).

3.3.3 Finish Coat

Finish with a two component urethane consisting of saturated polyester polyol resin mixed with aliphatic isocyanate which has a minimum of 50 percent solids by volume. Apply to a minimum dry film thickness of 0.05 to 0.076 mm (2 to 3 mils). Color shall be the manufacturer's standard.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated on contract drawings and documents. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.5.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.5.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.5.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.5.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.5.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 10 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.5.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with TIA-758:

a. Wire map (pin to pin continuity)

b. Continuity to remote end

c. Crossed pairs

d. Reversed pairs

e. Split pairs

f. Shorts between two or more conductors

3.5.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and

Attenuation Test. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 100 m(328 feet) minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14 for multimode fiber. Splice losses shall not exceed 0.3 db.

b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 1300 and 1550 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with TIA-455-46A for multimode and TIA-526-7 for single-mode fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA/EIA-455-204.

3.5.3 Soil Density Tests

b. Determine soil-density relationships as specified for soil tests in Section 31 00 00 EARTHWORK.

-- End of Section --

SECTION 34 71 13.19

ACTIVE VEHICLE BARRIERS
04/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM D3034	(2008) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM F2656	(2007) Standard Test Method for Vehicle Crash Testing of Perimeter Barriers

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3570	(2008) Carbon Steel Pipes for High Temperature Service

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J517	(2010) Hydraulic Hose

U.S. DEPARTMENT OF STATE (SD)

SD-STD-02.01	(2003; Rev A) Specification For Vehicle Crash Test of Perimeter Barriers and Gates

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009) Manual of Uniform Traffic Control Devices

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

UNDERWRITERS LABORATORIES (UL)

UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors

1.2 SYSTEM DESCRIPTION

Submit a complete list of equipment, materials, including industrial standards used and how they apply to the applicable component and manufacturer's descriptive data and technical literature, catalog cuts, and installation instructions. Furnish information necessary to document a minimum 1-year successful field operation performance history for each type of vehicle barrier installed. Barrier systems used shall be listed in either the Department of State (DoS) certified or Department of Defense (DoD) approved anti-ram vehicle barrier lists. Barrier widths shall be 'as certified/approved' on these lists. Alternatively, if a barrier system's width is between the widths of two listed barrier systems that are identical except for their widths, then that barrier system is also acceptable. Exceptions and acceptable widths will only be taken from the DoD anti-ram vehicle barrier list. The design and structural materials of the vehicle barrier furnished shall be the same as those used in the crash tested barrier. Crash test must have be performed and data compiled by an approved independent testing agency in accordance with either ASTM F2656 or SD-STD-02.01. Barriers tested and certified on the previous Department of State standard, SD-STD-02.01 and listed on the DoD approved anti-ram vehicle barrier list are also acceptable. Submit Data Package 4 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G
Equipment; G
Electrical Work; G

SD-03 Product Data

Barrier Systems
Spare Parts

SD-06 Test Reports

Field Testing

SD-10 Operation and Maintenance Data

Barrier Systems; G
Operating and Maintenance Instructions

1.4 DELIVERY, STORAGE, AND HANDLING

Protect components placed in storage from the weather, humidity, and temperature variation, dirt and dust, or other contaminants. Store structural materials on sleepers or pallets and protect them from rust and objectionable materials such as dirt, grease, or oil.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment used, after approval of the detail drawings. Include in the data a complete list of parts and supplies, with current unit prices and source of supply. Provide a manufacturer's standard recommended spare parts package, with current unit prices and source of supply complete with detailed manuals on parts replacement, with each barrier to facilitate 1 year of normal operation. Give particular consideration to system components which are not readily available from local or commercial sources and which are critical to the operation of the system.

PART 2 PRODUCTS

2.1 RETRACTABLE BARRIERS

When in the raised position, the total retractable barrier height above the roadway surface and width shall be as indicated in drawings. When in the lowered position, the retractable barrier shall extend no more than 16 mm (5/8 inch) above the roadway surface. Retractable barriers in the lowered position shall be capable of supporting a 142 kN (32,000 pound) axle load or a 71 kN (16,000 pound) wheel load. Design for this load shall be in accordance with AASHTO HB-17.

2.1.1 Powered Retractable Barrier

The retractable barrier shall be capable of 300 complete up/down cycles per hour. The retractable barrier motion shall be instantly reversible and shall be capable of raising the barrier from the lowered position to the raised position within 8 seconds during normal use, and within 2 seconds during an emergency. Also, the barrier shall be capable of being lowered from the raised position to the lowered position in not more than 3 seconds. Retractable barrier shall withstand a 6000 kg (15000 pound) vehicle at impact speed of 80 km/hour (40 mph) with maximum barrier deflection or vehicle penetration of .91 m (3 feet), unless otherwise indicated in contract drawings.

2.1.1.1 Failure Modes of Operation

The system shall be designed to remain in the last commanded position in the event of hydraulic, electrical, or mechanical failure. A manual pump, or other system, shall be included for operation of hydraulic barriers without power.

2.1.1.2 Electric Motors

Unless otherwise indicated, electric motors shall have totally enclosed, fan cooled enclosures. All couplings, motor shafts, gears, and other moving parts shall be fully guarded in accordance with 29 CFR 1910 Subpart O. Guards shall be removable without disassembling the guarded unit. For multiple barriers operated from a single hydraulic unit it is highly recommended that the electric motor be 3-phase.

2.1.1.3 System

The system shall be designed to maintain the barriers in the raised position, without inspection, for periods of time of up to 1 week. If a hydraulic system is used, it shall be equipped with pressure relief valves to prevent overpressure. The system shall not require continuous running of the motor to stay in the raised position, excluding the use of manual pinning to do so.

2.1.1.4 Hydraulic Power Unit

The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of minus 7 to plus 66 degrees C (20 to 150 degrees F). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below minus 7 degrees C (20 degrees F) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe, or a combination of flexible and carbon steel pipe. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D3034 Type PS 46 with minimum pipe stiffness of 46.

a. Flexible hydraulic lines shall be in accordance with SAE J517.

b. Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A106/A106M or KS D 3570.

2.1.1.5 Hydraulic Power Unit Enclosure

A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2.1.2 Manual Retractable Barriers

The manual barrier shall be capable of being raised and lowered by manual means such as levers or hydraulics requiring a maximum 267 N (60 pounds) of force. The manual mechanism shall contain a locking pin which accepts a padlock for securing the barrier when it is in the "UP" position. Retractable barrier shall withstand a 6000 kg (15000 pound) vehicle at impact speed of 80 km/hour (40 mph) with maximum barrier deflection or vehicle penetration of .91 m (3 feet), unless otherwise indicated in contract drawings. Barrier should be capable of being locked in the down position.

2.2 NAMEPLATES

Nameplate data shall be permanently attached to each vehicle barrier. The data shall be legibly marked on corrosion-resistant metal plates and shall consist of at least the following:

a. Manufacturer's name.

b. Model number.

c. Serial number.

d. Date of manufacture.

2.3 RETRACTABLE BOLLARDS

The total bollard height when in the raised position shall be no less than 750 mm (30 inches) above the roadway surface and shall have an outside diameter of no less than 200 mm (8 inches). A bollard system shall consist of a minimum of 3 bollards spaced no more than 915 mm (36 inches) from centerline to centerline of bollards across a 3.0 m (10 foot) roadway. Bollards in the lowered position shall be capable of supporting a 71 kN (16,000 pound) wheel load each. Design for this load shall be in accordance with AASHTO HB-17. Retractable barrier shall withstand a 6000 kg (15000 pound) vehicle at impact speed of 80 km/hour (40 mph) with maximum barrier deflection or vehicle penetration of .91 m (3 feet), unless otherwise indicated in contract drawings.

2.3.1 Powered Retractable Bollards

The retractable bollard shall be capable of 300 complete up/down cycles per hour. Bollards shall be capable of being raised or lowered within a 3 to 15-second range during normal use and within 2.5 seconds for emergency operations.

2.3.1.1 Failure Modes of Operation

The system shall be designed to prevent lowering of the barrier in the event of hydraulic, electrical, or mechanical failure. A manual pump, or other system, shall be included for operation of hydraulic and/or mechanical barriers without power.

2.3.1.2 Electric Motors

Unless otherwise indicated, electric motors shall have totally enclosed enclosures. For multiple barriers being operated from a hydraulic power unit it is highly recommended that the electric motor be 3-phase.

2.3.1.3 System

The system shall be designed to maintain the barriers in the raised position, without inspection, for period of time of up to 1 week. If a hydraulic system is used, it shall be equipped with pressure relief valves to prevent overpressure.

2.3.1.4 Hydraulic Power Unit

The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of minus 7 to plus 66 degrees C (20 to 150 degrees F) . A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range, if ambient temperatures below minus 7 degrees C (20 degrees F) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe, or a combination of flexible and carbon steel pipe. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D3034 Type PS 46 with minimum pipe stiffness of 46.

a. Flexible hydraulic lines shall be in accordance with SAE J517.

b. Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A106/A106M or KS D 3570.

2.3.1.5 Hydraulic Power Unit Enclosure

A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2.3.2 Manual Retractable Bollards

Manual bollards shall be capable of being raised and lowered utilizing a recessed handle on the top surface of the bollard or a manual hydraulic pump, either requiring a maximum 267 N (60 pounds) of force. A mechanism, that is lockable, shall be provided to secure the bollard in either the full "UP" or full "DOWN" position.

2.4 CRASH GATE

The crash gate shall consist of steel buttresses anchored into the ground and an above grade assembly consisting of a heavy steel structure or a combination of heavy steel and structural aluminum capable of being opened and closed. The height of the gate shall be a minimum of 2.1 m (84 inches) from the road surface to the top of the gate frame. The length shall close and protect a minimum 3.0 m (120 inch) clear opening. The maximum clear opening between the gate frame and end posts, between the bottom of the gate and finished grade, and between any grill work shall be 75 mm (3 inches).

2.4.1 Powered Crash Gate

The gate movement shall be controlled by an electro-mechanical or hydraulic gate operator consisting of an operator unit with required control circuits and operator station with remote control as indicated. The control and operating voltage shall be 24 vac (nominal)or 24 vdc. Unless otherwise indicated, motors shall have totally enclosed enclosures. Crash gate shall withstand a 6804 kg (15,000 pound) vehicle at impact speed of 80 km/hour (40 mph), with maximum barrier deflection or vehicle penetration of.91m (3 feet).

2.4.1.1 Failure Mode of Operation

The system shall be designed to prevent opening of the crash gate in the event of electrical or mechanical failure. A disconnect system for the gate drive shall be provided to allow manual operation of the barrier in the event of a power outage.

2.4.1.2 Hydraulic Power Unit

The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity within its operating range, even at constant heaviest use rate, for an ambient temperature range of minus 7 to plus 66 degrees C (20 to 150 degrees F) . A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below minus 7 degrees C (20 degrees F) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe, or a combination of flexible and carbon steel. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D3034 Type PS 46 with minimum pipe stiffness of 46.

a. Flexible hydraulic lines shall be in accordance with SAE J517.

b. Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A106/A106M or KS D 3570.

2.4.1.3 Hydraulic Power Unit Enclosure

A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2.4.2 Manual Crash Gate

The manual crash gate shall be capable of being hinged from either side. Hinge points of both buttresses shall each contain a locking pin with padlock acceptance for securing the crash gate in the closed position. The crash gate shall withstand a 6804 kg (15,000 pound) vehicle traveling at impact speed of 80 km/hour (40 mph), with a maximum gate deflection or vehicle penetration of up to 1 m (3 feet).

2.5 CRASH BEAM

The crash beam shall be an above-grade assembly that, in the "DOWN" position, shall present a visible obstacle to approaching vehicles. The height of the barrier shall be a minimum of 750 mm 30 inches as measured from the roadway surface to the centerline of the crash beam. The crash beam shall be capable of blocking a minimum road width of 3.0 m (120 inches). The crash beam end shall contain a locking pin with padlock acceptance for securing the crash beam when it is in the "DOWN" position. Crash beam shall withstand a 6804 kg (15,000 pound) vehicle traveling at 80 km/hour (40 mph), with maximum vehicle penetration of 6 m (20 feet) .

2.5.1 Powered Crash Beam

The crash beam shall be operated by means of a hydraulic power system. The crash beam shall be capable of being raised or lowered within an 8 to 15 second time range.

2.5.1.1 Failure Mode of Operation

A disconnect system for the crash beam shall be provided to allow manual operation of the barrier in the event of an electrical or mechanical failure.

2.5.1.2 Hydraulic Power Unit

The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of minus 7 to plus 66 degrees C (20 to 150 degrees F) . A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below minus 7 degrees C (20 degrees F) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe or a combination of flexible and carbon steel pipe. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D3034 Type PS 46 with minimum pipe stiffness of 46.

a. Flexible hydraulic lines shall be in accordance with SAE J517.

b. Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A106/A106M or KS D 3570.

2.5.1.3 Hydraulic Power Unit Enclosure

A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit components and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable exterior door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2.5.2 Manual Crash Beam

The crash beam shall be manually raised and lowered with the aid of a counterbalanced end requiring approximately 267 N (60 pounds) of force.

2.6 PORTABLE RETRACTABLE BARRIER

The portable retractable barrier shall be transportable and capable of manual and/or electro-mechanical operation. When in the raised position, the total barrier height and width shall be as indicated in the contract drawings . The barrier shall be equipped with entrance/exit ramps when the barrier extends more than 16 mm (5/8 inch) above the roadway surface. Retractable barriers in the lowered position shall be capable of supporting a 142 kN (32,000 pound) axle load or a 71 kN (16,000 pound) wheel load. Design for this load shall be accordance with AASHTO HB-17.

2.6.1 Powered Portable Retractable Barrier

The portable retractable barrier shall be capable of 300 complete up/down cycles per hour. The retractable barrier motion shall be instantly reversible and shall be capable of raising the barrier from the lowered position to the raised position within 8 seconds during normal use, and within 2 seconds during an emergency. Also, the barrier shall be capable of being closed from the raised position to the lowered position in not more than 3 seconds. Portable retractable barrier, when impacted by a 6818 kg (15000 pound) vehicle at impact speed of 48 km/hour (30 mph) shall disable the vehicle and allow it to travel no more than 15.2 m (50 feet) after impact. Portable power assisted retractable barriers shall be equipped with on and off ramps for smooth transition between surfaces when the barrier extends more than 16 mm (5/8 inch) above the roadway surface.

2.6.1.1 Failure Modes of Operation

The system shall be designed to prevent lowering of the barrier in the event of hydraulic, electric, or mechanical failure. A manual pump shall be included for operation of hydraulic and/or mechanical barriers without power.

2.6.1.2 Electric Motors

Unless otherwise indicated, electric motors shall have totally enclosed enclosures.

2.6.1.3 System

The system shall be designed to maintain the barriers in the raised position, without inspection, for periods of time of up to 1 week. If a hydraulic system is used, it shall be equipped with pressure relief valves to prevent overpressure.

2.6.1.4 Hydraulic Power Unit

The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of minus 7 to plus 66 degrees C (20 to 150 degrees F). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below minus 7 degrees C (20 degrees F) are expected. Flexible hydraulic lines shall be used for the connection of the hydraulic power unit to the barrier. Flexible hydraulic line working pressures shall exceed the maximum system relief pressure; flexible hydraulic lines shall be in accordance with SAE J517.

2.6.2 Manual Retractable Portable Barriers

The manual barrier shall be capable of being raised and lowered by manual means such as levers or hydraulics requiring a maximum 267 N (60 pounds) of force. The manual mechanism shall contain a locking pin which accepts a padlock for securing the barrier when it is in the "UP" position and shall also be capable of being locked in the "DOWN" position.

2.7 PORTABLE CRASH BEAM

The portable crash beam shall be an above-grade assembly that, in the "DOWN" position, shall present a visible obstacle to approaching vehicles. The height of the barrier shall be a minimum of 750 mm (30 inches) as measured from the roadway surface to the centerline of the crash beam. The crash beam shall be capable of blocking a minimum road width of 3.0 m (120 inches). The crash beam end shall contain a locking pin with padlock acceptance for securing the crash beam when it is in the "DOWN" position. Crash beam shall withstand a 6804 kg (15,000 pound) vehicle traveling at 48 km/hour (30 mph), with maximum vehicle penetration and/or barrier deflection of 6 m (20 feet).

2.7.1 Powered Portable Crash Beam

The portable crash beam shall be operated by means of a hydraulic power system. The crash beam shall be capable of being raised or lowered within an 8 to 15 second time range.

2.7.1.1 Failure Mode of Operation

A disconnect system for the portable crash beam shall be provided to allow manual operation of the barrier in the event of an electrical or mechanical failure.

2.7.1.2 Hydraulic Power Unit

The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of minus 7 to plus 66 degrees C (20 to 150 degrees F). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below minus 7 degrees C (20 degrees F) are expected. Flexible hydraulic lines shall be used for the connection of the hydraulic power unit to the barrier. Flexible hydraulic line working pressures shall exceed the maximum system relief pressure; flexible hydraulic lines shall be in accordance with SAE J517.

2.7.1.3 Hydraulic Power Unit Enclosure

A weather resistant enclosure shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit components and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2.7.2 Manual Portable Crash Beam

The crash beam shall be manually operated by means of a counter balanced system requiring approximately 267 N (60 pounds) of force.

2.8 ELECTRICAL WORK

Submit detail drawings containing complete wiring and schematic diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Motors, manual or automatic motor control equipment except where installed in motor control centers and protective or signal devices required for the operation specified herein shall be provided in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. All field wiring for loop detectors, communication lines, and power circuits shall have surge protection. Any wiring required for the operation specified herein, but not shown on the electrical plans, shall be provided under this section in accordance with Sections 26 20 00 INTERIOR DISTRIBUTION SYSTEM and 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.9 CONTROL PANEL

A control panel and control circuit shall be provided to interface between all barrier control stations and the power unit. A control panel shall be provided for the inbound lanes and a separate one for the outbound lanes where the barriers are located. The control station is defined as the main control panel and the remote control panel as shown. The control circuit shall contain all relays, timers, and other devices or an industrial programmable controller programmed as necessary for the barrier operation. The control panel shall allow direct interface with auxiliary equipment such as card readers, remote switches, loop detectors, infrared sensors, and sliding, swinging gate limit switches. Loop controllers shall not cause an automatic barrier raise following power loss or restoration. The enclosure shall be as indicated on the drawings. All device interconnect lines shall be run to terminal strips.

2.9.1 Voltage

The control circuit shall operate from a 120 volt 60 Hz supply. The control circuit voltage shall be 12 dc for all external control panels.

2.9.2 Main Control Panel

A main control panel shall be supplied to control barrier function. This panel shall have a key-lockable main switch with main power "ON" and panel "ON" lights. Buttons to raise and lower each barrier shall be provided. Barrier "UP" and "DOWN" indicator lights shall be included for each barrier. An emergency fast operate circuit (EFO) shall be operated from a push button larger than the normal controls and have a flip safety cover installed over the push button or toggle switch. The EFO shall also be furnished with an EFO-active light and reset button. The main control panel shall have a key lockable switch to arm or disable the remote control panel. An indicator light shall show if the remote control panel is enabled.

2.9.3 Remote Control Panel

A remote control panel, one panel for the inbound lane(s) and a separate panel for the outbound lane(s), shall have a panel "ON" light that is lit when enabled by a key lockable switch on the main control panel. Buttons to raise and lower each barrier shall be provided. Barrier "UP" and "DOWN" indicator lights shall be included for each barrier. The EFO shall be operated from a push button larger than the normal controls and have a flip safety cover installed over the push button or toggle switch.

Activation of either EFO will operate all barriers. The EFO shall be interconnected with an EFO-active light. When the remote control panel EFO is pushed, operation of the barrier will not be possible from this panel until reset at the main control panel.

2.10 MISCELLANEOUS EQUIPMENT

2.10.1 Safety Equipment

2.10.1.1 Barrier Systems Sensors

The barrier system sensors shall consist of the following:

a. Suppression Loops - Two inductive loops whose outputs shall be used to prevent barriers raising when a vehicle is within a prescribed distance of the barrier. The output of the loops shall override all barrier rise signals until one second after a vehicle clears the suppression loop.

b. Speed Loops - Two inductive loops whose output shall be used to signal the barrier controller of a vehicle approaching at a speed greater than the posted speed (11.2 m/sec (25 mph) or less (recommended)). The speed loops shall cause the barrier control panel to annunciate a warning sound alerting the guard to make a decision as to whether the barrier should be raised or not.

c. Wrong Way Loops - Two inductive loops whose output shall be used to signal the barrier control panel to annunciate a warning sound if a vehicle is attempting to enter the facility through the exit lane. The warning sound will alert the guard to make a decision as to whether the barrier should be raised or not.

The sensors shall be compatible with the barrier controller and shall function as part of a complete barrier control system.

2.10.1.2 Traffic Lights

Red/yellow 200 mm (8 inch) traffic lights shall be supplied for each entrance and exit to alert motorists of the barrier position. Traffic lights are not required for manual barriers. The yellow flashing light shall indicate that the barrier is fully open. All other positions shall cause the light to show red. Brackets shall be supplied to allow the light to be mounted a minimum 1.4 m (4.5 feet) above the roadway pavement on a 90 mm (3.5 inch) outside diameter metal post or mounted directly on the crash gate.

2.10.2 Warning Annunciator

Provide a warning annunciator built into the barrier control panel that produces a pulsing audible sound when the speed loop detects a vehicle entering the facility with excess speed. Provide a warning annunciator built into the barrier control panel that produces a continuous sound whenever a wrong way loop detects a vehicle entering from the exit. The warning annunciator shall sound until a warning annunciator silence reset button is pressed.

2.10.3 Heater

A waterproof barrier heater with a thermostat control and NEMA 4 junction box connection point shall be provided for de-icing and snow melting. The heater shall provide barrier operation to an ambient temperature of minus 40 degrees C (minus 40 degrees F). For retractable bollards, a 250-watt heater shall be provided for each bollard.

2.10.4 Signage

Signage shall read "Axle Weight Limit 9 Tons" and shall conform to MUTCD sign (R12.2).

2.10.5 Vertical Arm Gates (Traffic Arms)

Vertical arm gates shall have an opening and closing time of less than or equal to 5 seconds. The gates shall be capable of 500 duty cycles per hour as a minimum. Gate shall operate the arm through 90 degrees. Gate operators shall be supplied with single phase 120 volt motors. Each entry lane shall be provided with a vertical arm gate. Each gate shall be capable of being operated from a remote open-close push button station in each guard booth and the gatehouse for the respective entry lane. Gates shall have a hand-crank, or other means, which will allow manual operation during power failures. Gate arms shall be constructed out of wood, steel, fiberglass, or aluminum, as specified by the manufacturer for the given lengths as shown on the drawings. Gate arms shall be covered with 406 mm (16 inch) wide reflectorized red and white sheeting. Each gate shall be furnished with a spare gate arm. Gate operator cabinets shall be constructed of galvanized steel, or aluminum and shall be painted manufacturers standard color as approved. Each gate operator shall be provided with an obstruction detector that will automatically reverse the gate motor when an obstruction is detected. The obstruction detector shall be any of the following 3 types: An electronic loop vehicle detector buried in the road, a photocell electric eye mounted on the gate operator, or a safety strip mounted on the lower edge of the arm. The detector system shall be automatically deactivated when the arm reaches the fully lowered position. Slab size and anchorage for gate operator shall be in accordance with manufacturer requirements.

2.10.6 Vehicle Barrier Vertical Arm Gate (Traffic Arm)

A traffic arm, as a separate piece of equipment, will be included with each non-portable active vehicle barrier as part of the barrier safety operating system. This traffic arm shall automatically deploy (close) when the emergency up button is activated and open when the vehicle barrier is reset. This traffic arm will not be equipped with an automatic obstruction detector.

2.11 FINISH

Surfaces shall be painted in accordance with requirements of Section 09 90 00 PAINTS AND COATINGS. The roadway plate shall have a nonskid surface painted white with reflective red 100 mm (4 inch) wide red reflective stripes 100 mm (4 inches) apart. The barrier front shall be painted white and have 100 mm (4 inch) wide reflective red stripes 100 mm (4 inches) apart. The diagonal striping should point down and outward from the center of the device. Bollards shall be painted white with 50 mm (2 inch) wide reflective red diagonal stripes. The barrier crash gate shall be painted as specified by purchaser and the crash beam shall be painted white with 75 mm (3 inch) wide reflective red diagonal stripes.

2.12 CONCRETE

The concrete shall conform to Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.13 WELDING

Welding shall be in accordance with AWS D1.1/D1.1M.

2.14 PAVEMENT

After placement of the vehicle barrier, the pavement sections shall be replaced to match the section and depth of the surrounding pavement. Pavement shall be warped to match the elevations of existing pavement. Positive surface drainage, away from the vehicle barrier, shall be provided by pavement slope.

PART 3 EXECUTION

3.1 INSTALLATION

Perform installation in accordance with manufacturer's instructions and in the presence of a representative of the manufacturer. Manufacturer's representative shall be experienced in the installation, adjustment, and operation of the equipment provided. The representative shall also be present during adjustment and testing of the equipment. Show on the Drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including foundation and clearances for maintenance and operation. Include with the Detail drawings a copy of the Department of State certificate of barrier performance. If the active vehicle barrier is crash rated and/or certified, then the barrier system shall be installed in an 'as-tested' condition. Additional site investigation and construction will be required in order to accomplish this; except when a site specific crash test was performed where the exact site requirements were utilized in the crash test.

3.2 HYDRAULIC LINES

Place buried hydraulic lines in polyvinyl chloride (PVC) sleeves. Provide positive drainage from the hydraulic power unit to the barrier for drainage of condensation within the PVC sleeve.

3.3 PIT DRAINAGE

Provide a drain connection in each barrier that requires pit/vault type construction. Provide hookups between the storm drains.

3.4 ELECTRICAL

All control power wiring requiring compression terminals shall use ring-style terminals. Terminals and compression tools shall conform to UL 486A-486B. Roundhead screws and lock washers shall be used to provide vibration-resistant connections. Connections between any printed circuit cards and the chassis shall be made with screw connections or other locking means to prevent shock or vibration separation of the card from its chassis. The electrical power supply breaker for the hydraulic power unit shall be capable of being locked in the power on and power off positions.

3.5 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment supplied. The representative shall supervise the installation, adjustment, and testing of the equipment.

3.6 FIELD TRAINING

Provide a field training course for designated operating staff members. Training shall be provided for a total period of not less than 8 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance instructions. Submit one hard copy and one digital copy (.pdf - text searchable) of operation and maintenance manuals, a minimum of 2 weeks prior to field training. Manuals shall be approved prior to acceptance. Operation manuals shall outline the step-by-step procedures required for system startup, operation, and shutdown. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals shall include routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed. The manuals shall also include synthetic biodegradable hydraulic oil types to be used for ambient temperature ranges of minus 34 degrees C (minus 30 degrees F) to plus 66 degrees C (150 degrees F) to cover winter operation, summer operation, and ambient temperature ranges in between.

3.7 FIELD TESTING

Submit one digital copy (.pdf - text searchable) and one hard copy of test reports in booklet form showing all field tests, including component adjustments and demonstration of compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate with each test report the final position of controls. Upon completion of construction, perform a field test for each vehicle barrier. The test shall include raising and lowering the barrier, both electrically and manually, through its complete range of operation. Each vehicle barrier shall then be continuously cycled for not less than 30 minutes to test for heat build-up in the hydraulic system. Notify the Contracting Officer at least 7 days prior to the beginning of the field test. Furnish all equipment and make all necessary corrections and adjustments prior to tests witnessed by the Contracting Officer. Any conditions that interfere with the proper operation of the barrier disclosed by the test shall be corrected at no additional cost to the Government. Adjustments and repairs shall be done by the Contractor under the direction of the Contracting Officer. After adjustments are made to assure correct functioning of components, applicable tests shall be completed.

-- End of Section --

SECTION 34 71 13.26 31

VEHICLE GUARDRAIL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2012) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 307	(2012) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A 563M	(2007) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A 780/A 780M	(2009) Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1002	(2001) Hexagon Head Bolts and Hexagon Head Screws
KS B 1004	(2012) Square Head Bolts
KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS D 8308	(2001) Zinc Hot Dip Galvanizings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-07 Certificates

Metal Beam Guardrail; G.

Statement, signed by an official authorized to certify on behalf of the manufacturer, attesting that the metal beam guardrail meets the specified requirements.

PART 2 PRODUCTS

2.1 MATERIALS

Materials shall conform to the following:

2.1.1 Metal Beam Rail

The W-beam rail element shall be galvanized in accordance with ASTM A 123/A 123M or KS D 8308 minimum coating of 460 grams per square meter (1.5 ounces per square feet). Minimum metal thickness shall be 2.05 mm (12 gage).

2.1.2 Fasteners

Fasteners shall be galvanized and shall be in accordance with ASME B18.2.1, ASME B18.2.2, ASTM A 307, and ASTM A 563M; or KS B 1002, KS B 1004, and KS B 1012.

2.1.3 Concrete

Concrete for posts shall conform to requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE. Concrete shall have a minimum compressive strength of 24 MPa (3,500 psi) at 28 days.

2.1.4 Reinforcement

Reinforcement shall conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 GENERAL

Metal beam guardrail shall be installed to the lines and grades indicated. Damages to galvanized surfaces shall be repaired in accordance with ASTM A 780/A 780M.

3.2 EXCAVATION

Post holes shall be cleared of loose material. Waste material shall be spread where directed. The ground surface irregularities along the fence line shall be eliminated to the extent necessary to maintain a 50 mm (2 inches) clearance between the bottom of the fabric and finish grade.

3.3 POST INSTALLATION

Posts shall be set plumb and in alignment. Posts shall be set in concrete to the depth indicated on the drawings and backfill properly.

3.4 RAIL ELEMENTS

Erect rail elements in a smooth continuous line with the laps in the direction of traffic flow. Use bolts that extend at least 0.01 mm (0.0004 inch) but not more than 25 mm (1 inch) beyond the nuts. Insure that all bolts are tightened.

-- End of Section --

SECTION 34 73 13

MOORING AND GROUNDING POINTS FOR AIRCRAFT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A436	(1984; R 2011) Standard Specification for Austenitic Gray Iron Castings
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM B371/B371M	(2008; R 2013) Standard Specification for Copper-Zinc-Silicon Alloy Rod
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C94/C94M	(2014) Standard Specification for Ready-Mixed Concrete

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 407	(2012; TIA 11-1) Standard for Aircraft Fuel Servicing

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2011) Steel Bars for Concrete Reinforcement
KS D 3504	(2011) Steel Bars for Concrete

	Reinforcement
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

As-Built Drawings; G

SD-06 Test Reports

Concrete; G
Tests

SD-07 Certificates

Mooring Devices
Grounding Rods
Grounding Connectors
Copper Conductors
Reinforcing Steel

1.3 AS-BUILT DRAWINGS

Submit AS-Built Drawings that provide current factual information, including deviations from and amendments to the drawings and changes in the work, concealed and visible.

PART 2 PRODUCTS

2.1 METALS

Do not use combination of materials that forms an electrolytic couple, which accelerates corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such metals.

2.2 MOORING DEVICES

Mooring devices shall be cast in ductile iron 80-55-06 conforming to ASTM A436. The device shall be as shown in the contract drawings. Submit certificates of compliance on the devices stating that the mooring devices meet the specified requirements.

2.3 GROUNDING RODS

Grounding rods shall conform to UL 467 and shall be made of copper-clad steel. The rods shall be not less than 19 mm (3/4 inch) diameter and not less than 3 m (10 feet). The copper cladding shall conform to the applicable requirements of ASTM B371/B371M, Copper Alloy UNS No's. c 69400, c 69430, c 69440 or c 69450. The copper cladding shall be not less than 0.25 mm (0.010 inches) thick at any point and shall comply with adherence requirements and the banding requirements of UL 467. Submit certificates of compliance stating that the grounding rods meet the specified requirements. Rods shall be provided with a closed eye or shepherd's hook bend having an inside diameter of not less than 32 mm (1-1/4 inches). The rods shall be pointed unless used for flexible pavement. For flexible pavement, the rods shall have 19 mm (3/4 inch) American standard rolled threads for attachment of a bottom anchor and shall be equipped with a screw-type bottom having a wing diameter of not less than 152 mm (6 inches).

2.4 COPPER CONDUCTORS

Copper conductors shall be bare number 4 AWG copper wire conforming to ASTM B8. Submit certificates of compliance stating that the copper conductors meet the specified requirements.

2.5 GROUNDING CONNECTORS

Grounding connectors shall comply with UL 467 for the required application. Submit certificates of compliance stating that the grounding connectors meet the specified requirements.

2.6 CONCRETE

Submit complete concrete mix design including all cement, aggregate, and concrete tests and compliance certificates. Concrete shall be in accordance with Section 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS ASTM C94/C94M. The concrete shall be air entrained and have a minimum compressive strength of 40 MPa (6,000 psi). The concrete shall have the following properties: Nominal maximum aggregate size of 25 mm (1 inch), air content of 6 percent, and a maximum slump of 100 mm (4 inches) for drilled piers and 50 mm (2 inches) for all other applications.

2.7 REINFORCING STEEL

Reinforcing steel shall conform to ASTM A615/A615M Grade 40 or 60 for #4 tie bars or KS D 3504 and Grade 60 for #6 vertical bars. Steel shall be welded into cages in accordance with AWS D1.4/D1.4M and inserted securely in the piers, in position and alignment, as shown, prior to concrete placement. Submit certificates of compliance stating that the reinforcing steel meets the specified requirements.

PART 3 EXECUTION

3.1 MOORING POINTS IN NEW RIGID PAVEMENTS OR CONCRETE PADS

Install the mooring device within plus or minus 50 mm (2 inches) of the location shown on the contract drawings. The top of the mooring device shall be set within 6 mm (1/4 inch) of the plan pavement surface elevation, but not higher than the pavement surface. Install the mooring device prior to placement of the concrete pavement. Place concrete and reinforcement in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Hand finishing of the concrete around the mooring devices shall be kept to a minimum.

3.2 MOORING POINTS IN EXISTING RIGID PAVEMENTS

Install the mooring points in 305 plus or minus 13 mm (12 plus or minus

1/2 inch) diameter holes cored through the pavement. The core holes shall be drilled within plus or minus 38 mm (1-1/2 inches) of the location shown in the contract drawings. The mooring device and attached grounding rod shall be installed within plus or minus 13 mm (1/2 inch) of the center of the core hole. The top of the mooring device shall be installed within 6 mm (1/4 inch) of the surrounding pavement surfaces, but not higher.

3.2.1 Coring Requirements

Core the holes using rotary, non-percussion drilling techniques. The sides of the core hole shall be perpendicular to the pavement surface. Once the pavement is cored, the base course shall be excavated as shown in the drawings. The sides of the core hole shall be cleaned of latence and roughened by sand blasting. Place the concrete around the mooring device in two or more lifts. The first lift shall be placed to within 125 mm (5 inches) of the pavement surface and thoroughly consolidated by spud vibrators. The second lift shall be placed and also consolidated by internal vibration. The surface of the concrete shall be finished and textured to match the adjacent pavement surface and elevation. White pigmented curing compound meeting the requirements of COE CRD-C 300 or KS F 2540 shall be uniformly applied at a coverage of not more than 4.5 square meters per Liter (200 square feet per gallon).

3.2.2 Cleanup

Control all operations to minimize the amount of dust, dirt, debris and laitance in the work area. Clean all dirt, dust, debris, or laitance from coring or concreting operations, from the pavement surfaces prior to final acceptance.

3.3 MOORING POINTS INSTALLED IN DRILLED PIERS

Coordinate excavation of piers so that reinforcing steel and concrete placement is a continuous operation performed the same day that the excavation is completed. Excavations shall not be left open overnight. Place concrete within 3 hours after approval of the completed pier excavation. Pier drilling equipment shall have the minimum torque capacity and downward force capacity for the contract site conditions.

3.3.1 Government Inspection

The Contracting Officer will inspect each drilled pier excavation. Concrete shall not be placed until the excavation has been approved. Furnish the Contracting Officer all necessary equipment required for proper inspection of drilled pier excavations.

3.3.2 Installation Procedures

Excavate piers to the depths and dimensions shown. Piers shall be core drilled through pavements. Bottoms of piers shall be cleaned of loose or soft material and leveled. Excavated material shall be disposed of in accordance with Section 31 00 00 EARTHWORK. Perform the following:

a. The surrounding base courses, subgrade, and soil shall be adequately and securely protected against cave-ins, displacement of the surrounding earth, and retention of ground water by means of temporary steel casings. Casings shall have outside diameters not less than the indicated shaft sizes and shall be a minimum of 6 mm (1/4-inch) thick. Withdraw steel casings as the concrete is being placed, maintaining sufficient head of concrete within the casing to prevent extraneous material from falling in from the sides and mixing with the concrete. Casings may be jerked upward a maximum of 100 mm (4 inches) to break the bottom seal; but, thereafter, shall be removed with a smooth, continuous motion.

b. The inside of steel casings shall be thoroughly cleaned and oiled before reuse.

c. Water that flows into the excavations shall be continuously removed and all water shall be removed from the excavation bottom, to the extent possible, prior to concrete placement. The maximum permissible depth of water shall be 50 mm (2 inches). In the event of a severe water condition that makes it impossible or impractical to dewater the excavation, concrete shall be placed using underwater tremie after water movement has stabilized.

d. Continuously place concrete, ensuring against segregation and dislodging of excavation sidewalls; concrete shall completely fill the shaft. Concrete shall be placed by pumping or drop chutes in dry holes and by tremie or pumping in wet holes. The discharge shall be kept a minimum of 305 mm (1 feet) below the fresh concrete surface during placement. Concrete placement shall not be interrupted in any pier for more than 30 minutes. The upper 1.5 m(5 feet) of the concrete pier shall be vibrated.

e. Correct any pier out of center or plumb beyond the specified tolerance, as necessary for compliance; bear any cost of correction. Cross sections of shafts shall not be less than design dimensions. Piers shall be installed with top location deviating a maximum of 50 mm (2 inches) from centerline locations.

f. Install the mooring device within plus or minus 25 mm (1 inch) of the center of the drilled pier. The top of the mooring device shall be within 6 mm (1/4 inch) of the top of the pier, but not higher.

g. Replace, at no additional cost to the Government, piers found out of tolerance.

h. Provide protection around top of the excavation to prevent debris from being dislodged into the excavation and concrete.

3.4 GROUNDING POINTS

Locate the grounding points as shown on the contract drawings to within plus or minus 50 mm (2 inches).

3.4.1 Pavement Recess

The top of the grounding rod shall be set at or not more than 6 mm (1/4 inch) below the pavement surface grade. A recess 70 mm (2-3/4 inches) wide, and not more than 150 mm (6 inches) long, with a smooth rounded edge shall be provided in the pavement around the grounding point anchor eye to permit the entrance of lines into the eye and to allow for attachment of the grounding cable. The depth of the recess shall be no deeper than the bottom of the opening of the grounding point eye.

3.4.2 Installation

3.4.2.1 Existing Rigid Pavement

Install grounding rods in holes cored through the rigid pavement using rotary, non-percussion drilling techniques. The core holes shall have a minimum diameter of 150 mm (6 inches). The grounding rod shall be installed by pushing or driving the rod through the pavement base courses and subgrade. The installation technique chosen shall not damage the grounding rod or the pavement. Installation shall be completed by placing concrete around the grounding rod in two lifts with each lift consolidated with spud vibrators.

3.4.2.2 New Rigid Pavement

Install the grounding rod by pushing or driving the rod through the pavement base courses and subgrade prior to concrete placement. The installation technique chosen shall not damage the grounding rod. Hand finishing around the rod shall be kept to a minimum.

3.4.2.3 Flexible Pavement

Install grounding rods in portland cement concrete blockouts measuring 1.2 by 1.2 m (4 by 4 feet) in plan dimensions. The thickness and reinforcing details are shown on the contract drawings. Install the grounding rod by pushing or driving the rod through the pavement base courses and subgrade prior to concrete placement. The installation technique chosen shall not damage the grounding rod. Hand finishing around the rod shall be kept to a minimum.

3.4.3 Interconnection

Grounding rods within aircraft hangars shall be electrically interconnected to the hangar electrical grounding system with not less than a number 4 AWG bare copper conductor. Grounding rods installed at fueling hydrant outlets shall be electrically interconnected with the fuel piping with not less than a number 4 AWG bare copper conductor.

3.5 TESTS

Submit an independent testing agency's certified reports of inspections and tests, including analysis and interpretation of test results. Each report shall be properly identified. Describe Test methods and standards used. Measure resistance to ground tests as specified in NFPA 407. Submit test results to the Contracting Officer. Report to the Contracting Officer, immediately, any ground rods that have more than 10,000 ohms of resistance.

-- End of Section --

SECTION 40 05 13.96

WELDING PROCESS PIPING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2012) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS A3.0M/A3.0	(2010) Standard Welding Terms and Definitions
AWS B2.1/B2.1M	(2009) Specification for Welding Procedure and Performance Qualification
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME B31.1	(2014; INT 1-47) Power Piping
ASME B31.3	(2010) Process Piping
ASME B31.4	(2009) Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquid
ASME B31.5	(2013) Refrigeration Piping and Heat Transfer Components
ASME B31.8	(2010; Supplement 2010) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC I	(2010) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC II-C	(2010) BPVC Section II-Materials Part C-Specifications for Welding Rods Electrodes and Filler Metals
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC V	(2010) BPVC Section V-Nondestructive Examination

1.2 DEFINITIONS AND SYMBOLS

Definitions shall be in accordance with AWS A3.0M/A3.0. Symbols shall be in accordance with AWS A2.4.

1.3 PERFORMANCE REQUIREMENTS

Quality of all joint preparation, welding, and examination is the Contractor's responsibility for. Clearly identify and record all materials used in the welding operations. The inspection and testing defined in this specification are minimum requirements. Additional inspection and testing shall be the responsibility of the Contractor when it is deemed necessary to achieve the quality required.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Welding Operations

SD-06 Test Reports

Nondestructive Test Report

SD-07 Certificates

Qualifications
Welding Procedures Qualification
Certification

1.5 QUALIFICATIONS

Welding procedures, welders, and welding operators previously qualified by test may be accepted for the work without requalification, provided that all of the following conditions are fulfilled:

a. Copies of the welding procedures, the procedure qualification test records, and the welder and welding operator performance qualification test records are submitted and approved in accordance with paragraph SUBMITTALS.

b. Testing was performed by an approved testing laboratory or technical consultant or by the Contractor's approved quality assurance organization.

c. The welding procedures, welders, and welding operators were qualified in accordance with ASME BPVC SEC IX, or AWS B2.1/B2.1M, AR-2 level; and base materials, filler materials, electrodes, equipment, and processes conformed to the applicable requirements of this specification.

d. The requirements of paragraph "Renewal of Qualification" below are met and records showing name of employer and period of employment using the process for which qualified are submitted as evidence of conformance.

1.5.1 Welding Procedures Qualification

Record in detail and qualify the Welding Procedure Specifications for every proposed welding procedure. Qualification for each welding procedure shall conform to the requirements of ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5, or ASME B31.8 and to this specification. The welding procedures shall specify end preparation for butt welds including cleaning, alignment, and root openings. Preheat, interpass temperature control, and postheat treatment of welds shall be as required by approved welding procedures, unless otherwise indicated or specified. The type of backing rings or consumable inserts, if used, shall be described and if they are to be removed, the removal process shall be described. Copies of the welding procedure specifications and procedure qualification test results for each type of welding required shall be submitted in accordance with paragraph SUBMITTALS. Approval of any procedure does not relieve the Contractor of the sole responsibility for producing acceptable welds. Welding procedures shall be identified individually and shall be referenced on the detail drawings or keyed to the contract drawings.

1.5.2 Welder and Welding Operator Performance

Each welder and welding operator assigned to work shall be qualified in accordance with ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5, or ASME B31.8.

1.5.2.1 Certification

Before assigning welders or welding operators to the work, provide the Contracting Officer with their names together with certification that each individual is performance-qualified as specified. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

1.5.2.2 Identification

Identify each particular weld with the personal number, letter, or symbol assigned to each welder or welding operator. To identify welds, written records indicating the location of welds made by each welder or welding operator shall be submitted, and each welder or welding operator shall apply the personal mark adjacent to the welds using a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the Contracting Officer that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 1 m (3 foot) intervals. Identification by die stamps or electric etchers will not be allowed.

1.5.2.3 Renewal of Qualification

Requalification of a welder or welding operator is required under any of the following conditions:

a. When a welder or welding operator has not used the specific welding process for a period of 3 months; the period may be extended to 6 months if the welder or welding operator has been employed on some other welding process.

b. When a welder or welding operator has not welded with any process during a period of 3 months, all the personal qualifications shall be considered expired, including any extended by virtue of a., above.

c. There is specific reason to question the person's ability to make welds that will meet the requirements of the specifications.

d. The welder or welding operator was qualified by an employer, other than those firms performing work under this contract, and a qualification test has not been taken within the preceding 12 months.

e. Renewal of qualification for a specific welding process under conditions a., b., and d., above, needs to be made on only a single test joint or pipe of any thickness, position, or material to reestablish the welder's or welding operator's qualification for any thickness, position, or material covered under previous qualification.

1.5.3 NDE Personnel

All NDE personnel shall be qualified in accordance with the following requirements.

1.5.3.1 NDE Personnel

NDE personnel shall be certified, and a written procedure for the control and administration of NDE personnel training, examination, and certification shall be established.

1.6 REGULATORY REQUIREMENTS

This section covers the welding of pressure piping systems. Submit detail drawings showing location, length, and type of welds; and indicating postweld heat treatment and NDE as required. Deviations from applicable codes, approved procedures, and approved detail drawings will not be permitted without prior written approval. Materials or components with welds made offsite will not be accepted if the welding does not conform to the requirements of this specification, unless otherwise specified. Develop procedures for welding all metals included in the work. Welding shall not be started until welding procedures, welders, and welding operators have been qualified. Qualification testing shall be performed by an approved testing laboratory, or by the Contractor if approved by the Contracting Officer. Notify the Contracting Officer at least 24 hours in advance of the time and place of the tests. When practicable, perform the qualification tests at or near the worksite. Maintain current records of the test results obtained in the welding procedure, welding operator, welder performance qualifications, and nondestructive examination (NDE) procedures readily available at the site for examination by the Contracting Officer. The procedures for making transition welds between different materials or between plates or pipes of different wall thicknesses shall be qualified. ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5 or ASME B31.8 requirements for branch connections may be used in lieu of detailed designs. Unless otherwise specified, the choice of welding process shall be the responsibility of the Contractor. Safety precautions shall conform to AWS Z49.1.

1.7 DELIVERY, STORAGE, AND HANDLING

All filler metals, electrodes, fluxes, and other welding materials shall be delivered to the site in manufacturers' original packages and stored in a dry space until used. Packages shall be properly labeled and designed to give maximum protection from moisture and to insure safe handling.

1.7.1 Material Control

Materials shall be stored in a controlled access and clean, dry area that is weather tight and is maintained at a temperature recommended by the manufacturer. The materials shall not be in contact with the floor and shall be stored on wooden pallets or cribbing.

1.7.1.1 Damaged Containers

Low-hydrogen steel electrodes shall be stored in their sealed shipping container. If the seal is damaged during shipment or storage, and the damage is not immediately detected, the covered electrodes in that container shall be rebaked in accordance with the manufacturer's instructions prior to issuance or shall be discarded. If a container is damaged in storage and the damage is witnessed, the electrodes from that container shall be immediately placed in a storage oven. The storage oven temperature shall be as recommended by the manufacturer or the welding material specification.

1.7.1.2 Partial Issues

When a container of covered electrodes is opened and only a portion of the content is issued, the remaining portion shall, within 1/2 hour, be placed in a storage oven.

1.7.2 Damaged Materials

Materials which are damaged shall be discarded. Covered electrodes which are oil or water-soaked, dirty, or on which the flux has separated from the wire shall be discarded.

PART 2 PRODUCTS

2.1 MATERIALS

Provide welding materials which comply with ASME BPVC SEC II-C. Welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

2.2 Local Products

Local materials manufactured in Republic of Korea authorized by U.S. Army Corps of Engineers Far East District Local Materials Committee may be permitted to be used in lieu of standard products. As a minimum, these materials should be certified and compliant with listed Korean Industrial Standards (KS) and are subject to Contracting Officer's approval.

PART 3 EXECUTION

3.1 WELDING OPERATIONS

Perform welding in accordance with qualified procedures using qualified welders and welding operators. Submit detailed procedures which define methods of compliance with contract drawings and specifications. Submit inspection and material procurement records and system and material testing and certification records. Submit written records and drawings indicating location of welds made by each welder or welding operator. Submit Nondestructive Test Report.

Welding shall not be done when the quality of the completed weld could be impaired by the prevailing working or weather conditions. The Contracting Officer will determine when weather or working conditions are unsuitable for welding. Welding of hangers, supports, and plates to structural members shall conform to Section 05 05 23 WELDING, STRUCTURAL.

3.1.1 Base Metal Preparation

Oxy-fuel cutting shall not be used on austenitic stainless steel or nonferrous materials.

3.1.2 Weld Joint Fit-Up

Parts that are to be joined by welding shall be fitted, aligned, and retained in position during the welding operation by the use of bars, jacks, clamps, or other mechanical fixtures. Welded temporary attachments shall not be used except when it is impractical to use mechanical fixtures. When temporary attachments are used, they shall be the same material as the base metal, and shall be completely removed by grinding or thermal cutting after the welding operation is completed. If thermal cutting is used, the attachment shall be cut to not less than 6 mm (1/4 inch) from the member and the balance removed by grinding. After the temporary attachment has been removed, the area shall be visually examined.

3.1.3 Preheat and Interpass Temperatures

Preheat temperatures shall meet the requirements specified by ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5 or ASME B31.8. However, in no case shall the preheat be below 10 degrees C (50 degrees F) for ferritic steel or austenitic stainless steel, or 0 degrees C (32 degrees F) for nonferrous alloys. The maximum interpass temperatures shall not exceed 149 degrees C (300 degrees F) for austenitic stainless steels, nickel alloys, and copper alloys; and 260 degrees C (500 degrees F) for carbon steels. Preheat techniques shall be such as to ensure that the full thickness of the weld joint preparation and/or adjacent base material, at least 75 mm (3 inches) in all directions, is at the specified temperature. Preheating by induction or resistance methods is preferred. When flame heating is used, only a neutral flame shall be employed. Oxy-fuel heating shall not be used on austenitic stainless steel or nickel-alloy materials; however, air-fuel heating is acceptable if controlled to insure that the surface temperature does not exceed 66 degrees C (150 degrees F). Interpass temperatures shall be checked on the surface of the component within 25 mm (1 inch) of the weld groove and at the starting location of the next weld pass, and for a distance of about 150 mm (6 inches) ahead of the weld, but not on the area to be welded.

3.1.4 Production Welding Instructions

a. Welding shall not be done when the ambient temperature is lower than minus 18 degrees C(0 degrees F).

b. Welding is not permitted on surfaces that are wet or covered with ice, when snow or rain is falling on the surfaces to be welded, or during periods of high winds, unless the welders and the work are properly protected.

c. Gases for purging and shielding shall be welding grade and shall have a dew point of minus 40 degrees C (minus 40 degrees F) or lower.

d. Back purges are required for austenitic stainless steels and nonferrous alloys welded from one side and shall be set up such that the flow of gas from the inlet to the outlet orifice passes across the area to be welded. The oxygen content of the gas exiting from the purge vent shall be less than 2 percent prior to welding.

e. The purge on groove welds shall be maintained for at least three layers or 5 mm (3/16 inch).

f. Removable purge dam materials shall be made of expandable or flexible plugs, such as plexiglass, plywood (which shall be dry when used), etc. Wood dams shall be kiln-dried quality. Nonremovable purge dams and purge dam adhesives shall be made of water soluble materials. Purge dams shall not be made of polyvinyl alcohol.

g. Any welding process which requires the use of external gas shielding shall not be done in a draft or wind unless the weld area is protected by a shelter. This shelter shall be of material and shape appropriate to reduce wind velocity in the vicinity of the weld to a maximum of 8 km/hour(5 mph (440 fpm)).

h. Welding of low-alloy and hardenable high-alloy steels may be interrupted provided a minimum of at least 10 mm (3/8 inch) thickness of weld deposit or 25 percent of the weld groove is filled, whichever is greater, and the preheat temperature is maintained during the time that welding is interrupted. If the temperature falls below the minimum preheat temperature before all welding has been completed on a joint, or, where required, before post weld heat treatment, a liquid penetrant or magnetic particle examination shall be performed to insure sound deposited metal before reheating. Welding of other materials may be interrupted without restriction provided a visual inspection is performed before welding is resumed.

i. Tack welds to be incorporated in the final welds shall have their ends tapered by grinding or welding technique. Tack welds that are cracked or defective shall be removed and the groove shall be retacked prior to welding. Temporary tack welds shall be removed, the surface ground smooth, and visually inspected. For low-alloy and hardenable high-alloy steels, the area shall be magnetic particle examination inspected.

j. When joining ferritic steel pressure piping components to austenitic stainless steel pressure piping components and postweld heat treatment is required, the following requirements apply:

(1) The weld-end preps of ferritic steel components, which are to be welded to austenitic stainless steel, shall be buttered with one of the following weld filler metals and shall conform to the specified requirements: ASME BPVC SEC II-C, SFA 5.14, Classification ERNiCr-3; or ASME BPVC SEC II-C, SFA 5.11, Classification ENiCrFe-2.

(2) The ferritic steel weld-end prep shall be buttered, receive a postweld heat treatment as required by ASME B31.1 or ASME B31.3 or

ASME B31.4 or ASME B31.5 or ASME B31.8 and then be machined with the applicable weld-end preparation. After machining, the buttered layer shall be a minimum of 6 mm (1/4 inch) thick.

(3) Pressure piping transition joints shall be completed using ERNiCr-3 or ENiCrFe-2 weld filler metals. No further postweld heat treatment shall be performed.

k. When joining ferritic steel pressure piping components to austenitic stainless steel pressure piping components and postweld heat treatment is not required, prepare and weld the joint using either ERNiCr-3 or ENiCrFe-2 filler metals. For service temperatures of 93 degrees C (200 degrees F) or less, stainless filler metal 309 ASME BPVC SEC II-C, SFA 5.4 or 5.9 is permissible in lieu of the nickel-based alloys.

l. Grinding of completed welds is to be performed only to the extent required for NDE, including any in-service examination, and to provide weld reinforcement within the requirements of ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5 or ASME B31.8. If the surface of the weld requires grinding, reducing the weld or base material below the minimum required thickness shall be avoided. Minimum weld external reinforcement shall be flush between external surfaces.

3.1.5 Postweld Heat Treatment

a. Postweld heat treatment shall be performed in accordance with ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5, or ASME B31.8. Temperatures for local postweld heat treatment shall be measured continuously by thermocouples in contact with the weldment.

b. Postweld heat treatment of low-alloy steels, when required, shall be performed immediately upon completion of welding and prior to the temperature of the weld falling below the preheat temperature. However, postweld heat treatment may be postponed after the completion of the weld, if, immediately after the weld is completed, it is maintained at a minimum temperature of 149 degrees C (300 degrees F) or the preheat temperature, whichever is greater, for 2 hours per 25 mm (1 inch) of weld thickness.

c. For low-alloy steels, the cooling rates shall be such that temper embrittlement is avoided.

3.2 EXAMINATIONS, INSPECTIONS, AND TESTS

Visual and NDE shall be performed by the Contractor to detect surface and internal discontinuities in completed welds. The services of a qualified commercial inspection or testing laboratory or technical consultant, approved by the Contracting Officer, shall be employed by the Contractor. All tack welds, weld passes, and completed welds shall be visually inspected. In addition, magnetic particle or liquid penetrant examination shall be performed on root passes. Radiographic, Liquid penetrant, Magnetic particle, or Ultrasonic examination shall be required as indicated in TABLE I. When inspection and testing indicates defects in a weld joint, the weld shall be repaired by a qualified welder in accordance with paragraph CORRECTIONS AND REPAIRS.

TABLE I. MANDATORY MINIMUM NONDESTRUCTIVE EXAMINATIONS

Type Weld	Piping Service Conditions and Nondestructive Test		
	Temperatures over 400 degrees C and at all pressures.	Temperatures between 177 degrees C and 400 degrees C inclusive and at pressures above 7100 kPa.	All others.
Butt Welds (Girth and Longitudinal)	RT for NPS over 50 mm MT or PT for NPS 50 mm and less.	RT for over 50 mm NPS with thickness over 20 mm. Visual for all sizes with thickness 20 mm or less.	Visual for all sizes and thicknesses.
Welded Branch Connections (Size indicated is branch size) (See Note 7)	RT for NPS over 100 mm MT or PT for NPS 100 mm and less.	RT for branch over 100 mm NPS and thickness of branch over 20 mm inch. Visual for all sizes with branch thickness 20 mm or less.	Visual for all sizes and thicknesses.
Fillet, Socket Attachment and Seal Welds	PT or MT for all sizes and thicknesses.	Visual for all sizes and thicknesses.	Visual for all sizes and thicknesses.

TABLE I. MANDATORY MINIMUM NONDESTRUCTIVE EXAMINATIONS

Type Weld	Piping Service Conditions and Nondestructive Test		
	Temperatures over 750 degrees F and at all pressures.	Temperatures between 350 degrees F and 750 degrees F inclusive and at pressures above 1,025 psig.	All others.
Butt Welds (Girth and Longitudinal)	RT for NPS over 2 inch MT or PT for NPS 2 inches and less.	RT for over 2 inch NPS with thickness over 3/4 inch. Visual for all sizes with thickness 3/4 inch or less.	Visual for all sizes and thicknesses.
Welded Branch	RT for NPS over	RT for branch over	Visual for

TABLE I. MANDATORY MINIMUM NONDESTRUCTIVE EXAMINATIONS

Type Weld Connections (Size indicated is branch size) (See Note 7)	Piping Service Conditions and Nondestructive Test		
	4 inch MT or PT for NPS 4 inches and less.	4 inch NPS and thickness of branch over 3/4 inch. Visual for all sizes with branch thickness 3/4 inch or less.	all sizes and thicknesses.
Fillet, Socket Attachment and Seal Welds	PT or MT for all sizes and thicknesses.	Visual for all sizes and thicknesses.	Visual for all sizes and thicknesses.

NOTES TO TABLE I

(1) All welds must be given a visual examination in addition to type of specific nondestructive examination specified.

(2) NPS - nominal pipe size.

(3) RT - Radiographic examination; MT - magnetic particle examination; PT - liquid penetrant examination.

(4) RT of branch welds shall be performed before any nonintegral reinforcing material is applied.

(5) The thickness of butt welds is defined as the thicker of the two abutting ends after end preparation.

(6) Temperatures and pressures shown are design.

(7) In lieu of radiography of welded branch connections when required above, liquid penetrant or magnetic particle examination is acceptable and, when used, shall be performed at the lesser of one half of the weld thickness or each 13 mm (1/2 inch) of weld thickness and all accessible final weld surfaces.

(8) For nondestructive examination of the pressure retaining component, refer to the standards listed in applicable code or the manufacturing specifications.

(9) Fillet welds not exceeding 6 mm (1/4 inch) throat thickness which are used for the permanent attachment of nonpressure retaining parts are exempt from the PT or MT requirements of the above table.

3.2.1 Random NDE Testing

When random radiographic, liquid penetrant, magnetic particle, or ultrasonic examination is required, test a minimum of 10 percent of the total length or number of piping welds. The welds inspected shall be selected randomly, but the selection shall include an examination of welds made by each welding operator or welder. If all of the additional welds inspected meet the quality requirements, the entire group of welds represented shall be accepted and the defective welds shall be repaired. If any of the additional welds inspected also fail to meet the quality requirements, that entire group of welds shall be rejected. The rejected welds shall be removed and rewelded, or the rejected welds shall be 100 percent inspected and all defective weld areas removed and rewelded.

3.2.2 Visual Inspection

Weld joints shall be inspected visually as follows:

a. Before welding - for compliance with requirements for joint preparation, placement of backing rings or consumable inserts, alignment and fit-up, and cleanliness.

b. During welding - for cracks and conformance to the qualified welding procedure.

c. After welding - for cracks, contour and finish, bead reinforcement, undercutting, overlap, and size of fillet welds.

3.2.3 NDE Testing

NDE shall be in accordance with written procedures. Procedures for radiographic, liquid penetrant, magnetic particle ,or ultrasonic tests and methods shall conform to ASME BPVC SEC V. The approved procedure shall be demonstrated to the satisfaction of the Contracting Officer. In addition to the information required in ASME BPVC SEC V, the written procedures shall include the timing of the NDE in relation to the welding operations and safety precautions.

3.2.4 Inspection and Tests by the Government

The Government will perform inspection and supplemental nondestructive or destructive tests as deemed necessary. The cost of supplemental NDE will be borne by the Government. The correction and repair of defects and the reexamination of weld repairs shall be performed by the Contractor at no additional cost to the Government. Inspection and tests will be performed as required for visual inspection and NDE, except that destructive tests may be required also. When destructive tests are ordered by the Contracting Officer and performed by the Contractor, and the specimens or other supplemental examinations indicate that the materials and workmanship do not conform to the contract requirements, the cost of the tests, corrections, and repairs shall be borne by the Contractor. When the specimens or other supplemental examinations of destructive tests indicate that materials or workmanship do conform to the specification requirements, the cost of the tests and repairs will be borne by the Government. When destructive tests are made, repairs shall be made by qualified welders or welding operators using welding procedures which will develop the full strength of the members cut. Welding shall be subject to inspection and tests in the mill, shop, and field. When materials or workmanship do not conform to the specification requirements, the work may be rejected at any time before final acceptance of the system containing the weldment.

3.3 ACCEPTANCE STANDARDS

3.3.1 Visual

The following indications are unacceptable:

a. Cracks.

b. Undercut on surface which is greater than 1 mm (1/32 inch) deep.

c. Weld reinforcement greater than 5 mm (3/16 inch).

d. Lack of fusion on surface.

e. Incomplete penetration (applies only when inside surface is readily accessible).

f. Convexity of fillet weld surface greater than 10 percent of longest leg plus 0.76 mm (0.03 inch).

g. Concavity in groove welds.

h. Concavity in fillet welds greater than 2 mm (1/16 inch).

i. Fillet weld size less than indicated or greater than 1.25 times the minimum indicated fillet leg length.

3.3.2 Magnetic Particle Examination

The following relevant indications are unacceptable:

a. Any cracks and linear indications.

b. Rounded indications with dimensions greater than 5 mm (3/16 inch).

c. Four or more rounded indications in a line separated by 2 mm (1/16 inch) or less edge-to-edge.

d. Ten or more rounded indications in any 3870 square mm (6 square inches) of surface with the major dimension of this area not to exceed 150 mm (6 inches) with the area taken in the most unfavorable location relative to the indications being evaluated.

3.3.3 Liquid Penetrant Examination

Indications with major dimensions greater than 2 mm (1/16 of an inch) shall be considered relevant. The following relevant indications are unacceptable:

a. Any cracks or linear indications.

b. Rounded indications with dimensions greater than 5 mm (3/16 inch).

c. Four or more rounded indications in a line separated by 2 mm (1/16 inch) or less edge-to-edge.

d. Ten or more rounded indications in any 3870 square mm 6 square inches) of surface with the major dimension of this area not to exceed 150 mm (6 inches) with the area taken in the most unfavorable location relative to the indications being evaluated.

3.3.4 Radiography

Welds that are shown by radiography to have any of the following discontinuities are unacceptable:

a. Porosity in excess of that shown as acceptable in ASME BPVC SEC I, Appendix A-250.

b. Any type of crack or zone of incomplete fusion or penetration.

c. Any other elongated indication which has a length greater than:

(1) 6 mm (1/4 inch) for "t" up to 19 mm (3/4 inch) inclusive. Where "t", here and below, pertains to the thickness of the weld being examined; if a weld joins two members having different thickness at the weld, "t" is the thinner of these two thicknesses.

(2) 1/3 "t" for "t" from 19 mm (3/4 inch) to 57 mm (2-1/4 inch), inclusive.

(3) 19 mm (3/4 inch) for "t" over 57 mm (2-1/4 inch).

d. Any group of indications in line that have an aggregate length greater than "t" in a length of "12t", except where the distance between the successive indications exceeds 6L where L is the longest indication in the group.

3.3.5 Ultrasonic Examination

Where discontinuities are interpreted to be cracks, lack of fusion, and incomplete penetration, they are unacceptable regardless of length. Linear-type discontinuities are unacceptable if the amplitude exceeds the reference level and discontinuities have lengths which exceed the following:

a. 6 mm (1/4 inch) for "t" up to 19 mm (3/4 inch). Where "t", here and below, is the thickness of the weld being examined; if the weld joins two members having different thicknesses at the weld, "t" is the thinner of these two thicknesses.

b. 8 mm (1/3 inch) for "t" from 19 to 57 mm (3/4 to 2-1/4 inch).

c. 19 mm (3/4 inch) for "t" over 57 mm (2-1/4 inch).

3.4 CORRECTIONS AND REPAIRS

Defects shall be removed and repaired as specified in ASME B31.1 or ASME B31.3, ASME B31.4, ASME B31.5,or ASME B31.8 unless otherwise specified. Disqualifying defects discovered between weld passes shall be repaired before additional weld material is deposited. Wherever a defect is removed, and repair by welding is not required, the affected area shall be blended into the surrounding surface eliminating sharp notches, crevices, or corners. After defect removal is complete and before rewelding, the area shall be examined by the same test method which first revealed the defect to ensure that the defect has been eliminated. After rewelding, the repaired area shall be reexamined by the same test method originally used for that area. Any indication of a defect shall be regarded as a defect unless reevaluation by NDE or by surface conditioning shows that no disqualifying defects are present. The use of any foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

-- End of Section --